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VOLUME 28 FEBRUARY, 1944 NUMBER 1

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INTRODUCING THE CONTRIBUTORS

C. R. ADDINALL ("Recent Chemotherapeutic Advances") became director of library services at Merck and Company ten years ago, after having been engaged for several years in chemical research. As a research chemist he investigated especially nitrogen ring compounds and alkaloids. He has taught chemistry at Harvard, the university at which he received his undergraduate and graduate education. Dr. Addinall delivered the paper which SCIENCE EDUCATION publishes in this issue at the November meeting of the New Jersey Science Teachers' Association.

J. G. MANZER ("Simple; Isn't It?") is president of the New Jersey Science Teachers' Association. Mr. Manzer has had a varied experience in American and Canadian schools. He has taught in high schools so small that he was the entire faculty—principal and sole teacher—and in large schools such as Trenton Central High School, where he is head of a science department of a dozen teachers. In addition, he has been an instructor of prospective teachers.

PHILIP P. KOTLAR ("Biology and Human Life") became a teacher, so he says, "in order to associate with normal people," entering the profession after a term as assistant director of research at the New York County penitentiary. As his article indicates, he is keenly interested in the personal and social implications of what he is teaching. At present he is especially concerned with helping children understand the causes of their behavior and that of other people. His own graduate studies in psychology and the medical sciences, pursued at Columbia and New York Universities, give him an unusual background for his work. His teaching experience has included all grades from one through twelve.

LOUISE G. DREHER ("A Chemistry Class Visits a Foundry") has likewise had both elementary and secondary school teaching experience. In both undergraduate and graduate work at the University of Pennsylvania, she majored in chemistry. She is especially interested in emphases which will enable high school students to see the significance of chemistry in community activities.

DONALD G. DECKER ("Biology and Human Life") devoted last year to an attempt to identify relationships between the natural resources of Colorado and the activities of the people of the state. This year he is spending much of the time not taken up with teaching on the work of a committee on the reorganization of the general education curriculum at Colorado College of Education. Dr. Decker has studied at Ypsilanti Normal School in Michigan, at Colorado College of Education, and at Teachers College, Columbia.

JAMES D. TELLER ("A Calendar of the Birthdays of Chemists") has contributed articles on a number of subjects to a variety of scientific and educational journals. This is his second appearance in the pages of SCIENCE EDUCATION; many readers will no doubt recall his first contribution, a paper on Thomas Henry Huxley, published in the issue for December, 1941.

ELSA MARIE MEDER ("Ninth Graders' Concepts of Energy") has been a member of the Bureau of Educational Research in Science at Teachers College, Columbia University, since 1940. She has had experience as a high school science teacher, as a biochemical research worker, and as a technical librarian for a large industrial concern.

GEORGE W. HUNTER ("Six Hundred Teachers Look at Science Trends") needs no introduction to the readers of SCIENCE EDUCATION. Generations of high school boys and girls have studied one or more of his many textbooks, and teachers-in-train-

ing in many places have studied his book on the teaching of science in junior and senior high schools. He is a member of many organizations devoted to scientific and educational research. He is an associate editor of this journal.

FRANCIS D. CURTIS ("Testing as a Means of Improving Instruction") has been at the University of Michigan since 1924. Like Dr. Hunter, Dr. Curtis is an associate editor of SCIENCE EDUCATION, and he, too, is known for his textbooks and for his work in educational research. The Curtis *Digests* have been of inestimable service to many science teachers and research workers.

CHARLES G. GRAHAM ("Visual Instruction in the Teaching of the Secondary Sciences") is at present an Instructor in General Science at Berea College in Kentucky, the school where he completed his own undergraduate work. He holds a Master's degree from George Peabody College and a Ph.D. from the University of Kentucky. Dr. Graham is not a new contributor to SCIENCE EDUCATION. The January–February issue of 1941 contained an article by him entitled, "Some Data Pertinent to Textbooks of General Science."

CHARLES GRAMET ("Vicarious Visits") was for many years a biology teacher in New York City high schools until, as often happens with good teachers, he was assigned duties of an administrative nature. At present he is giving full time to administrative work with the High School Division of the City Board of Education. He has long taken an active interest in the development of visual education in the New York schools.

PAUL F. BRANDWEIN ("Some Comments on the Annual Science Talent Search") is a member of the editorial board of *The Teaching Biologist* and a past president of the organization which publishes it, The New York Association of Biology Teachers. Dr. Brandwein has engaged actively in research both in education and in the biological sciences.

SCIENCE EDUCATION

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EDITORIAL

WITH this issue SCIENCE EDUCATION begins its twenty-eighth year of publication. Once called *General Science Quarterly,* its name was changed in 1929 to indicate its broadening scope.

Now SCIENCE EDUCATION is again reconsidering its editorial policies, with a view to serving teachers more effectively in the present dynamic period. A meeting of the Board of Directors of Science Education, Incorporated, was called for this purpose, and as a result of the discussions a committee was appointed and charged with the responsibility of making the journal more serviceable to all science teachers and others concerned with science education. To this end, there will be reports of recent advances in scientific research that are affecting our ways of living; descriptions of procedures in the classrooms of good teachers; suggestions for field trips, laboratory work, and the use of visual aids; and specimens of evaluation instruments. Articles on research in science education will continue to be published and the book reviews and abstracts of current periodical literature will, of course, be retained.

The Committee solicits the suggestions of readers of SCIENCE EDUCATION for improving the journal. It is hoped that a sufficient number of ideas will be contributed to make possible the inclusion of a "Readers Department" in each of the next few issues.

FLORENCE G. BILLIG
GERALD S. CRAIG
ELLSWORTH S. OBOURN
S. RALPH POWERS
W. G. WHITMAN, *Chairman*

RECENT CHEMOTHERAPEUTIC ADVANCES

C. R. Addinall
Merck and Company, Inc., Rahway, N. J.

"Life is short and art long; occasion fleeting; experience fallacious; and judgment difficult."
—Hippocrates, "The Aphorisms"

THE GERM THEORY OF DISEASES

BETWEEN 1860 and 1880, the work of Louis Pasteur gradually led to the discovery of the microbial nature of contagious disease. During the same period the labors of Lister, the researches of Robert Koch, and the further work of Pasteur on the inoculation of animals against chicken cholera and anthrax, converted the scientific world to the germ theory of disease—an idea which made rapid progress between 1880 and 1900, when the parasites which caused most of the common diseases were recognized, grown in pure culture, and described. Among these "parasites" or "germs" are many different creatures which use the human body as their host and thereby cause disease. Large, well-organized parasites such as tapeworms, liver flukes, and hookworms, head the list, but among the microscopic or ultramicroscopic organisms which Pasteur or Lister would have classified as "germs" are three chief classes comprising animal parasites (protozoa), vegetable parasites (bacteria and fungi), and the ultramicroscopic viruses.

THE COMING OF THE SULFANILAMIDES

Against the attack of this host of parasites mankind has two main arsenals of weapons—those fashioned after nature's own mode of warfare and the man-made "magic bullets" of synthetic drugs. In the use of the synthetic drugs, the main problem is to devise an agent which will reach the parasite in the tissues and serve to eliminate it with the minimum of danger and inconvenience to the host. Much progress has been made in the solution of this problem. Between the years 1910 and 1935, the period between the discovery of salvarsan and the announcement of prontosil, remedies for almost every protozoal disease had been found—Bayer 205 and tryparsamide for sleeping sickness; atebrine and plasmoquin, in addition to quinine, for malaria; yatren (and emetine) for amebiasis; and the antimony compounds such as fouadin and neostibosan for bilharziasis and kala azar.

But, as Hörlein pointed out in his now famous speech to the Royal Society in 1935, in which he announced the first successful specific against the bacterial diseases, the possibility of combating infectious diseases with chemotherapeutically active substances depends to a large extent on the nature of the pathogenic organism. Today, in the sulfanilamides, mankind has a powerful weapon against the onslaught of the bacteria. The development of successful defensive weapons against the virus diseases is still a task for the scientists of the future.

NATURAL CHEMOTHERAPEUTIC AGENTS

As far back as the time of Pasteur, it was recognized that when typhoid and diphtheria organisms, pathogenic staphylococci, and other bacteria were added to the soil they rapidly disappeared. Since then, antagonistic effects of one organism on another have been investigated and it now is well established that in mixed cultures of micro-organisms, such as occur in soil, the presence of a particular species may result in the partial or even complete suppression of the growth of the other species. It is becoming clear that the explanation often lies in the fact that the products of metabolism of one micro-organism, though

relatively harmless to the parent organism, may be harmful or sometimes extremely toxic to an organism of a different species. Moreover, if the nontoxic metabolic products of an organism are antagonistic to pathogenic organisms giving rise to disease, the possibility arises of using this property to combat disease and, further, of isolating a series of new, naturally occurring, chemotherapeutic agents.

Thus, as far back as 1899, Emmerich and Loew isolated from the green pus-producing organism, Pseudomonas aeruginosa (B. pyocyaneus), a substance they called "pyocyanase" which, even in low concentrations, had a marked destructive effect upon diphtheria, cholera, typhoid, and plague organisms. However, oft repeated attempts by various investigators failed in the isolation of any purified product of therapeutic value. The idea of the antagonism between micro-organisms was similarly employed when, in later years, Metchnikoff proposed the introduction of pure cultures of lactic acid bacteria into food in order to repress the proteolytic bacteria in the intestinal canal, which were supposed to bring about intoxication of the human system. The formation of metabolic products by molds has been the subject of an intensive study by Raistrick from 1922 onwards. This immense undertaking has resulted in the isolation of some fifty mold products of known chemical constitution which, at the present time, are being subjected to systematic investigation for antibacterial properties. In a review made in 1932, Raistrick advanced ample evidence of the outstanding synthetic powers of the lower fungi which (in common with bacteria, yeasts, actinomycetes, etc.) can produce from carbohydrates and a simple source of nitrogen such widely differing substances as pyrones and benzopyrones, quinones, phenolic acids, fatty acids, complex carbohydrates, fats, and sterols. To Raistrick there appeared to be definite evidence that some of these specific metabolic products formed part of a defensive system elaborated by the organism to suppress the growth of other organisms. As an illustration he cited the description by Fleming, in 1929, of the production by a species of Penicillium of a broth-culture filtrate (called by its discoverer "penicillin") which had very specific bactericidal properties. Raistrick ended his review with the pregnant sentence: "These and many other problems awaiting solution indicate, in the writer's opinion, a very bright future for the young science of mycological chemistry."

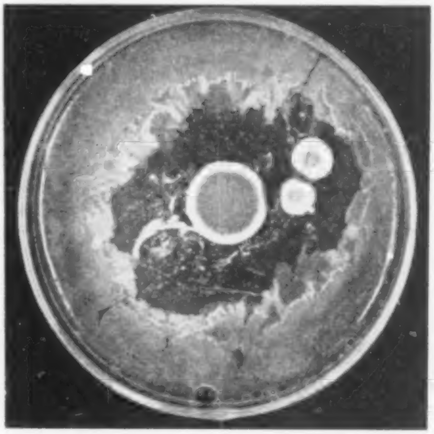

FIG. 1. Colony of Penicillium notatum, showing surrounding zone of inhibition. This is the phenomenon noted by Fleming in 1929, which led to his discovery of penicillin.

While working with staphylococcus variants, Fleming had set aside a number of culture plates on a laboratory bench which became contaminated with various microorganisms. It was noticed that around a large colony of contaminating mold the staphylococcus colonies became transparent and obviously were being dissolved. To find out something about the properties of the bacteriolytic substance formed in the mold culture which had diffused into the surrounding medium, the mold was grown as a pure culture in nutrient broth at room temperature for one to two weeks. The mold grew on the surface as a white, fluffy

mass, changing in a few days to a dark green felt. The broth became bright yellow and yielded filtrates which had marked action on the pyogenic cocci and the diphtheria group of bacilli, though the coli-typhoid and influenza-bacillus groups of bacteria and the enterococci were quite insensitive. The broth filtrate, penicillin, was found to be nontoxic to animals in enormous doses and also nonirritant. Fleming suggested that "penicillin may be an effective antiseptic for application to, or injection into, areas infected with penicillin-sensitive microbes." He also observed that the power of the alkaline broth was lost in ten to fourteen days, but that it was preserved longer by neutralization.

PENICILLIN AS A CHEMOTHERAPEUTIC AGENT

The suggestion of Fleming was not entirely disregarded, but the significance of his findings was neglected during the years that witnessed the triumphal entry and progress of the sulfonamides. In turn, however, the study of these compounds focused attention on chemotherapy, on the theories of the mode of action of drugs, and the relation of changes in the chemical structure of compounds to their varying physiological activity. In the midst of this interest in chemotherapy, Dubos, at the Rockefeller Institute for Medical Research, announced in February, 1939, the isolation of an unidentified spore-bearing bacillus (later identified as B. brevis) capable of causing the lysis of living gram-positive cocci from soil to which suspensions of these cocci had been added over a long period of time. From this bacillus a crude but highly bactericidal substance, tyrothricin, was isolated, and later this, in turn, gave the crystalline compounds gramicidin and tyrocidine hydrochloride, the former bacteriostatic and the latter highly bactericidal *in vitro* for gram-positive organisms. Pneumococcic infections in mice were treated successfully with gramicidin, but the compound proved to be highly toxic both to mice and to dogs. The work of Dubos, however, convinced the Oxford workers, Chain and Florey (who previously had been interested in the active substance lysozyme as it occurs in egg white, saliva, tears, etc., and which now is known to be produced by certain species of the micro-organisms termed actinomycetes), that it would be profitable to conduct a systematic investigation of the chemical and biological properties of the penicillin described by Fleming. It is to be noted that although Fleming gave the name penicillin to a broth-culture filtrate, the term is being more and more used to designate the as yet nonisolated, pure, active principle.

In their history making paper, "Penicillin as a Chemotherapeutic Agent," in August, 1940, Chain and Florey revealed that they had devised methods for obtaining a considerable yield of penicillin and for making a rapid assay of its inhibitory power. From the culture medium a brown powder was obtained which was freely soluble in water. The powder and solution, stable for some time, had very great antibacterial power. In dilutions of one in several hundred thousand, the preparation inhibited, by interfering with multiplication, the growth of many micro-organisms. Of these, in particular, streptococci, staphylococci, and Clostridium septique were found to be susceptible of inhibition in therapeutic tests on mice. Moreover, though not apparently related to any chemotherapeutic substance then in use, it was particularly remarkable for its activity against the anaerobic organisms associated with gas gangrene.

Further observations on penicillin by this group of workers showed the low toxicity of sufficiently purified penicillin when applied to body tissues; proved the inability of blood, pus, and tissue-breakdown products to prevent its inhibitory action; and demonstrated that in heavily infected wounds, where sulfonamide drugs seem to have little beneficial action, the

activity of penicillin was influenced only to a minor extent by the number of bacteria to be inhibited.

The benefits to be derived from such a chemotherapeutic agent for the treatment of the wounded in the armed forces were obvious to the medical profession of the embattled peoples of Britain, and arrangements were made by the Rockefeller Foundation for Florey and his co-worker, Heatley, who had devised the assay method and developed and supervised the production procedures in Oxford, to visit the United States. After a visit to the Northern Regional Laboratory of the Department of Agriculture at Peoria, Illinois, where studies were initiated on the cultural characteristics of the parent mold, Penicillium notatum, and methods of purifying penicillin, Florey consulted with several commercial companies in the hope that they might undertake production development.

The tempo of the work was quickened by the entry of the United States into the war after the attack at Pearl Harbor, on December 7, 1941, and today some eighteen or more companies are engaged in the production of penicillin. In no instance has preparation advanced very far beyond the pilot-plant stage; in the majority, it still is in the stage of laboratory development, though some companies now are building large plants for ultimate commercial production.

PRODUCTION DEVELOPMENT

The difficulties which confront large-scale production are very great. They arise from the fact that in the metabolism of the mold only very minute amounts of penicillin are formed, and these only after days of growth. Many gallons of culture fluid must be worked up in order to prepare as much as one ounce of the finished product. In culture broths, penicillin is inherently unstable and also is destroyed by bacterial and other contaminations to which the culture fluids are highly susceptible. Difficulties have been encountered in choosing the most productive strains of the mold and the most suitable culture media, in the development of methods for extraction and purification, and in the stabilization of the purified product.

The difficulties which have to be overcome in producing penicillin on a commercial scale may perhaps be best realized by reviewing, briefly, the main steps in its preparation. Since strains of the mold of different origin vary widely in their ability to secrete penicillin, it is important to select a high-potency strain of Penicillium notatum for the stock culture. To avoid spontaneous loss of potency in the use of this selected strain, an aqueous suspension of the spores of this potent variant is mixed with sterilized sand and the mixture is dried. This soil-spore mixture constitutes the master culture which can be preserved indefinitely in the refrigerator.

FIG. 2. Typical mature surface pellicle of Penicillium notatum. Note the thick, wrinkled growth covered with spores and the presence of droplets containing chrysogenin on the surface. This typical yellow pigment also is evident in the medium. The wrinkles are caused by excessive growth within the rigid confines of the vessel.

To provide a subculture for manufacturing purposes, a loopful of the soil-spore mixture is spread evenly over the surface of solidified Sabouraud's agar. Incubation for four to six days gives an abundance of grass green spores with which more agar in Roux bottles is inoculated, thus providing sufficient inoculum for several hundreds of flasks containing a suitable liquid medium. In the course of a seven to fourteen day incubation, the spores, floating on the surface, germinate and form white cottonlike vegetative surface patches, ultimately spreading out into a complete, though thin, surface carpet, and meanwhile exuding the yellow pigment, chrysogenin, into the liquid medium. About the sixth day the white mat begins green-spore formation and the pellicle commences to wrinkle until, finally, it bears numerous convolutions. During this process penicillin is excreted into the medium in amounts dependent on the potency of the culture, the nature and content of the medium, the hydrogen ion concentration, and the presence of trace elements. Below a certain pH level, another antibacterial substance, notatin, may be formed at the expense of the production of penicillin, and, dependent on the presence or absence of traces of zinc and other materials, the yields of penicillin may be affected to a marked degree.

FIG. 3. Photomicrograph of spore apparatus in surface culture of Penicillium notatum (X530).

At peak production the liquid medium is separated from the mold by filtration and the clear liquid broth then is extracted with suitable organic solvents. The penicillin thus extracted is converted into an aqueous solution of the sodium salt of penicillin. This orange-yellow solution is suitably concentrated and yields a light orange-colored solid product which is distributed in ampoules containing 10,000; 100,000; and 1,000,000 Oxford units of potency. This arbitrary unit is defined by Florey and Jennings as that amount of penicillin which, when dissolved in 50 cc. of meat-extract broth, just inhibits completely the growth of the test strain of S. aureus.

CHEMOTHERAPEUTIC ACTIVITY OF PENICILLIN

Organisms susceptible *in vitro* to the bactericidal or bacteriostatic action of penicillin include pneumococcus, staphylococcus, meningococcus, gonococcus, and lactobacillus. Organisms which have proved insusceptible to penicillin include Haemophilus influenzae, B. dysenteriae, B. pyocyaneus, B. prodigiosus, among others.

H. J. Robinson has shown that a purified penicillin, containing 400 units per mg., killed mice only in doses of about 1.5 g. per kg. In mice infected with streptococci, pneumococci, and staphylococci, penicillin was more effective than sulfanilamide, sulfathiazole, or sulfadiazine, weight for weight. Penicillin also has greater permanency of protection and greater rapidity of absorption. Experiments on mice by Hobby, Meyer, and Chaffee led them to conclude that penicillin is highly effective against hemolytic streptococci and pneumococci, and nontoxic within the range of therapeutic dosage. Against strains of types I, II and VIII pneumococci resistant to sulfadiazine, penicillin was proved effec-

tive both *in vitro* and in mice by McKee and Rake.

CLINICAL INDICATIONS

Penicillin has proved remarkably effective in the treatment of infections produced by the pneumococcus, gonococcus, hemolytic streptococcus, and hemolytic staphylococcus aureus, although, in general, it is not effective against gram-negative organisms, with the exception of the gonococcus and meningococcus. As indicated by *in vitro* experiments, there is no doubt but that a variety of other organisms are susceptible to penicillin. According to the report of Richards: "There is good reason for the belief that it is far superior to any of the sulfonamides in the treatment of Staphylococcus aureus infections with and without bacteriemia, including acute and chronic osteomyelitis, cellulitis, carbuncles of the lips and face, pneumonia and empyema, infected wounds and burns. It is also extremely effective in the treatment of hemolytic streptococcus, pneumococcus and gonococcus infections which are resistant to sulfonamides. It has not been found effective in the treatment of subacute bacterial endocarditis. Studies of the results of its local application are still inadequate."

THE PRESENT AND THE FUTURE

The production of penicillin, by extraction of the metabolic product of a fungus, always will be, of necessity, a laborious and comparatively expensive, time-consuming task, involving large plants, vast amounts of solvents, and much equipment.

At the present time, intense efforts are being made to expand production to the point where penicillin will be available in significant quantities not only for war casualties returned to this country but also for our armed forces overseas. Until these demands have been met, only limited supplies for civilian needs can be expected. With increased production and with the findings made available by the thus extended clinical investigations, there can be but little doubt that proof will be advanced of the present belief and hope that this new approach to chemotherapy, illustrated by penicillin, may bless the human race with another in a series of chemotherapeutic agents for triumphant use in the continual struggle against disease.

SIX HUNDRED TEACHERS LOOK AT SCIENCE TRENDS

GEORGE W. HUNTER
Claremont Colleges, California

IN 1940 a very comprehensive questionnaire was sent out by the writer to the science teachers in about 2,600 representative junior and senior high schools of the United States from which 655 answers were received. The findings that follow were obtained from the responses given by somewhat over six hundred teachers to a series of questions concerned with certain trends and problems of science teaching in the secondary schools of this country. The publication and mailing of the questionnaire were made possible by a grant from the Joint Research Committee of Claremont Colleges, Claremont, California.

In the interpretation of answers to a questionnaire a certain amount of subjectivity has to be allowed for on the part of the person who tabulates the findings. In the present case the writer has attempted to reduce this to a minimum. He believes that the material that follows indicates quite clearly the thinking of the teachers who answered the series of questions. Where possible the actual answer of the respondent has been given. In the summaries made, the answers have been segregated under general headings defined by the writer, but no attempt has been made

to read into the answers of the respondents anything that was not there.

Generally speaking, the answers given were consistent and there were few contradictions of statement on the part of the individual respondents. In some schools there were differences of opinion, especially between the teachers of general science and life science on the one hand, and the teachers of physics and chemistry on the other. Such variations in opinion are to be expected because of the difference in the age levels of the pupils taught, and because of the difference in objectives for the science courses at these two different levels. In the tabulations that follow, these differences do not usually appear, but in the breakdown of the answers an attempt has been made to show the psychological and pedagogical reasons for the answers given.

The states responding to these questionnaires were listed under the following headings: New England, Middle, Southern, North Central, Rocky Mountain, and Pacific. Distribution was as follows:

New England States 50: Connecticut, 12 replies; Maine, 10; Massachusetts, 20; New Hampshire, 4; Rhode Island, 2; Vermont, 2.

Middle States 131: Delaware, 3 replies; District of Columbia, 2; Maryland, 3; New Jersey, 17; New York, 67; Pennsylvania, 39.

Southern States 138: Alabama, 6 replies; Arkansas, 3; Florida, 10; Georgia, 5; Kentucky, 11; Louisiana, 5; Mississippi, 7; Oklahoma, 33; North Carolina, 11; South Carolina, 4; Tennessee, 2; Texas, 29; Virginia, 8; West Virginia, 4.

North Central States 175: Illinois, 25 replies; Indiana, 24; Iowa, 28; Michigan, 32; Minnesota, 9; Missouri, 19; Ohio, 21; Wisconsin, 14.

Rocky Mountain States 88: Arizona, 5 replies; Colorado, 14; Idaho, 4; Kansas, 17; Montana, 10; Nebraska, 15; Nevada, 2; New Mexico, 6; North Dakota, 2; South Dakota, 9; Utah, 3; Wyoming, 2.

Pacific States 76: California 52 replies; Oregon, 8; Washington, 16.

Total for the United States 655.

The five questions which furnish the material for this paper follow:

1. Are your science courses more closely related to each other than they were ten years ago?

2. Is the pendulum swinging away from the life sciences and physical sciences toward the social sciences in your school? (Many of the respondents objected, perhaps rightly, to the use of the term "social sciences," and wished it replaced by the term "social studies.")

3. Do you favor the establishment of "applied science" courses *to take the place of* the pure science?

4. Should the "applied" course only supplement the "pure"?

5. Would you favor replacing individual laboratory work by demonstration in the science you teach? Give reasons for your answer.

A tabulation of the answers to the above questions appears in Table I.

TABLE I

Question	New England		Middle		Southern		North Central		Rocky Mt.		Pacific		Total U.S.		Total Answers
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
1.	36	5	130	23	112	21	126	18	65	10	51	20	520	97	617
2.	18	29	38	92	37	104	42	89	19	60	23	57	177	431	603
3.	11	25	46	83	35	95	46	97	34	48	29	54	201	402	603
4.	25	10	97	33	94	29	94	27	62	17	56	16	428	132	560
5.	11	25	27	95	36	83	30	96	19	55	25	51	148	405	553

INTERRELATIONS OF COURSES

It is evident that a majority of science teachers believe that the science courses in the schools of today are more closely related to each other than they were ten years ago, only 15.7 per cent of the respondents answering in the negative to question 1. This is to be expected, for with the advent of general science and its spread to the junior high school there is bound to be somewhat closer correlation of the sciences than in the past. A similar question asked in a similar questionnaire sent out in 1930 gave a like picture, as in this case about 13 per cent of the respondents answered that there was little or no correlation between the sciences at the high school level. Evidently the movement has been in progress for at least twenty years. These statements correlate rather closely with the answers given in the present questionnaire to the question: "Do your advanced courses gain anything from the general science courses as now given?" A recent paper [1] shows that over 50 per cent of the teachers of biology and about 50 per cent of the teachers of physics believe that general science has been of value to their students. To a lesser degree this seems to be true for chemistry. Evidently the general science courses are factors in this movement toward correlation of science subject matter at the secondary school level.

SCIENCE ENROLLMENTS

The second question: *"Is the pendulum swinging away from the life sciences and physical sciences toward the social sciences in your school?"* was asked because of the emphasis placed by modern curriculum makers on the social studies. The advent of the core curriculum, with the all too frequent omission of science from the core at the junior high school level, made this question timely. Here there was considerable difference of opinion. A little over 29.2 per cent of the respondents believed that science was losing to the social studies, while around 70 per cent said that science was holding its place in the curriculum. A breakdown of the answers by states revealed some interesting findings. In Delaware, Maryland, Georgia, Minnesota, South Dakota, and Colorado 50 per cent or more of the respondents said that there was a distinct falling away from science to the social studies. Several other states revealed a rather close division of answers on this question. Maine had a ratio of 4 (yes) to 5 (no); Massachusetts, 8 to 14; Connecticut, 6 to 7; Texas, 12 to 16; and Oregon, 3 to 4. While the swing away from science is more noticeable at the junior high school level, it is interesting to note that in certain states where curriculum committees have been directed by members of the staffs of certain teachers colleges, and where the "core curriculum" idea has been planted, a loss in science holdings was reported. The notable exception was the state of Virginia, but here the answers received (2 to 5) were probably too few to give the true picture. Several of the respondents qualified their answers by making such statements as:

> "Both are increasing"; "socialization, correlation and integration have taken place"; "both have gained"; "life sciences, 'no'; physical sciences, 'yes'"; "much socialization has taken place"; "in our high schools, 'yes'." Several teachers placed question marks in the spaces for "yes" and "no" indicating a lack of facts on which to base their judgments.

To offset the apparent loss of science we find indications that in many parts of the country science is gaining ground. This is seen in the answers of respondents which indicate that changes are rapidly going on to make science more functional. There is apparently a strong movement in biology, or "life science," toward consumer education and more functional applications in the lives of those who take the courses. This is also seen in the introduction of

[1] Hunter, George W., and Parker, Mary Alice. "The Subject Matter of General Science." *School Science and Mathematics*, December, 1942.

advanced "general science" courses, or science survey, descriptive chemistry and descriptive physics. Enrollments in all courses that are directed toward meeting the real needs of students in an age of practical science are increasing. In many instances rather full descriptions of such courses accompanied the answers to the questionnaire. There is considerable evidence to show that science teachers are becoming awake to the fact that science must be made more vital and more functional if it is to retain its present place in the curriculum, and that they are changing their courses to meet the new demands of the present day clientele who need to be prepared to meet new conditions of life. Some of this evidence is found in the following excerpts taken from the answers of respondents:

"Our biology courses have increased more than any of our science work. This was made possible by the offering of a general biology course for the non-college group."

"We have five separate courses in chemistry: Business, general 1, general 2, college and technical."

"Since we have separated boys and girls in physics our enrollment has gone up 600 per cent."

"Some courses of non-technical nature are offered to students who cannot or will not take technical work."

"Applied chemistry is offered to commercials."

"Courses of study are being reorganized, de-emphasizing college preparation and emphasizing the statement, 'Know your environment.'"

"Establishment of 'Science Survey' for those low I.Q.'s who have difficulty with general science."

"A school survey shows students place biology as first in interest and value to them. The only change is that there is less stress on the technical and more on the practical aspect."

"Science is more directly related to the everyday home experience of the students."

"We really make provision for individual differences in our physics laboratory, some pupils accomplishing nearly twice the minimum requirement."

"Industrial hygiene is especially designed to give vocational pupils the necessary skills in the protection of their bodies and health."

Many schools and city school systems report curriculum changes in science are now under way in an attempt to reach the non-college group. An example of such a revision is seen in the following statement:

"Our science program is in process of revision toward a more directly applied type based on the needs of the community, and making more use of community activities."

Still more evidence is obtained from another section of the questionnaire. This portion asked whether the courses in science listed by the respondents had gained or lost in relative registration during the ten year period which had elapsed since publication of a previous questionnaire in 1930,[2, 3] or whether the number of students had remained relatively stationary. Most schools increased in population during the past ten years, so the increase in science enrollment had to be expressed as relative to school enrollment. Table II, page 19, given by state groupings, and based on about 600 answers, shows the picture.

Table II shows the area of the North Central States lagging in science enrollment increases, while the New England States appear at the head of the list in increases in enrollments. Can it be that conservative New England has seen the light before the North Central area? The figures were not expected but are given as statistical evidence.

Broken down by subjects, the results are shown in Table III.

Careful analysis of the returns shows clearly that many of the chemistry and physics courses showing gains in enrollment are of the *non-college-preparatory* type. Obviously the actual enrollments in general science and biology courses have increased greatly; college preparatory chemistry has gained somewhat while college preparatory physics in many schools has lost ground. In many schools the enrollments in general science and biology are very large, sometimes being required in a given year, while the enrollments in

[2] Hunter, George W. "The Sequence of Science in the Junior and Senior High School." *Science Education*, December, 1931.

[3] Hunter, George W. "Science Sequence in the Junior and Senior High Schools." *School Science and Mathematics*, February, 1933.

TABLE II

SCIENCE ENROLLMENTS, 1940, IN 600 HIGH SCHOOLS AS COMPARED WITH SCIENCE ENROLLMENTS, 1930

	Courses Showing Relative Increase in 1940 Over 1930	Courses Having About the Same Enrollment	Courses Having Relatively Fewer Students in 1940	Totals	Per Cent Showing Increase
New England	102	35	17	154	66.23
Middle	225	81	71	377	59.65
Southern	245	96	32	373	65.68
N. Central	109	103	86	298	33.55
R. Mountain	128	79	37	244	57.14
Western	98	56	43	197	49.75
Totals U. S.	907	450	286	1,643	55.20

TABLE III

SCIENCE ENROLLMENTS BY SUBJECTS, 1940, COMPARED WITH 1930 ENROLLMENTS

	Gain in Enrollment	Per Cent Gain	Same	Loss in Enrollment
General Science	228	57.00	117	55
Biology (Life Science)	264	71.90	72	31
Chemistry	180	56.96	79	57
Physics	127	40.44	88	99
Agriculture	43	62.31	17	9
Science Survey, etc.	44	89.80	4	1

chemistry and physics, being advanced subjects, are rather small. This naturally would make for an increase in science enrollments. Then many schools are introducing courses in general or non-mathematical physics, descriptive chemistry and physics, consumer science or science survey, all of which add considerably to the science enrollments at the upper levels of the high school. So we may safely assume that science enrollments, even in the physical sciences, are gaining ground, although it is a different kind of science course that is emerging.

"APPLIED SCIENCE"

In answer to the third question: *"Do you favor the establishment of 'applied courses' to take the place of pure science?"* we find differences of opinion. About one-third of the respondents (33.55 per cent) answered in the affirmative, while 66.45 per cent answered "No." Analysis of the answers by state groupings gives some unexpected results. The Rocky Mountain States come out most strongly in favor of the applied courses in science, 41.46 per cent answering in the affirmative; the Pacific States gave 34.94 per cent saying "yes"; the North Central States had 32.18 per cent answering in the affirmative; the New England States had 30 per cent answering "yes"; the Middle States gave 25.66 per cent saying "yes," while the Southern States, which we might think would be among the more radical, were the most conservative, only 26.92 per cent answering in the affirmative. Some respondents qualified their answers by such statements as:

"Both have their place"; "for some pupils"; "at the junior high school level, 'yes'"; "not entirely"; "to some extent"; "balance them"; "have been debating this for years and haven't made up my mind"; "within reason"; "we have both"; "only for technical pupils," etc., etc.

The consensus seems to indicate that science courses should have applications of a practical nature but not of necessity should all be applied science.

A rather complete sampling of answers was made to see if the junior high school answers favored the applied courses, but this was not evidenced in the answers. Rather it appeared that both junior and senior high school respondents were influenced by clientele, location of school, type of community, or the individual philosophy of the person who answered the question. Schools that were distinctly college preparatory answered, as we would expect, in the negative; experimental schools and those affected by the so-called "progressive" point of view either qualified their answers or said "yes."

The fourth question: *"Should the 'applied' course only supplement the 'pure'?"* was supplementary to the third question, and in the light of the qualified answers given above, correlated rather closely with it. Of the 560 respondents answering the question, 428, or 74.43 per cent, answered in the affirmative. Most of the qualified answers here indicate that for certain groups and especially for individuals in the lower quartiles of intelligence, the applied courses should be used. Many schools have already established supplementary science courses, especially at the high school level. Such courses have already been mentioned in a previous paper [4] and will be discussed later under another heading.

LABORATORY OR DEMONSTRATION?

The fifth question: *"Would you favor replacing individual laboratory work by demonstrations in the science you teach?"* was given with the belief that thinking teachers would discriminate with reference to the use of laboratory work in the science curriculum. This was what happened, for, by and large, teachers of science answered the question in a way that showed they know the real purpose of laboratory work and how and when the demonstration should be used. They showed that they were familiar with the newer aspects of the laboratory-demonstration controversy, and that they were able also to discriminate between the uses of the two methods. While there were some answers that showed bias, most of the respondents were truly scientific in the answers given. Many showed that they were not only familiar with the experimental evidence, but that they had tried the experiment for themselves. In the analysis of the answers that follows, the writer has not attempted to give an interpretation of the answers but has merely acted as a compiler of data.

Somewhat over 73 per cent (73.238 per cent) of the respondents answered "no" to the question, while about 27 per cent gave a more or less qualified "yes." As we would suspect, those who believed that they would replace laboratory work by demonstration were for the most part teachers in junior high schools. Although the rank and file of teachers at the senior high school level were in favor of continuance of laboratory work, there were many who gave reasons why laboratory exercises, as they are now given, should be replaced by something that means more than the "busy work" which so often occupies the time of our laboratory classes. Some even questioned laboratory values in terms of modern psychology. Such trends are refreshing and lead us to have faith in the coming generation of science teachers who mix modern psychology with their reasoning. It was also encouraging to find that many teachers were aware that laboratory work has assumed a different place in teaching, now that we have given up the idea of "training the faculties," and that unless we are interested in obtaining certain techniques and skills, laboratory work is not as important as we once believed.

[4] Hunter, George W., and Spore, Leroy. "Science Sequence and Enrollments in the Secondary Schools of the United States." *Science Education*, December, 1941, and February, 1942.

In the analysis that follows, grouping of reasons for giving laboratory work are given under several general categories. The most used reason for laboratory work was that *the learning of certain techniques and skills* could be best obtained through laboratory work. Eighty-two respondents gave reasons such as the following:

"Acquires skills in handling apparatus," 17; "teaches techniques needed in college courses," 12; "manipulation techniques important," 11; "manipulation of apparatus learned," 8; "gives opportunity to work with hands," 6; "develops skills," 5; "gets practice in certain skills," 5; other reasons, 18.

The second most used reason given was:

"We learn by doing," 68; "learn by doing," 5; "we learn more by doing," 2; "get more by doing it yourself," 3.

Pupil interest was the third category on the list, with 45 respondents. Of these, 33 gave student interest, 12 gave:

"Enjoyment," 3; "like to do things themselves," 3; "motivation through laboratory," 2; "more interested in their own activities," 2; other reasons, 2.

Problem solving came fourth with 28 scattering answers. Reasons given were:

"Learn to find out by themselves"; "learn to use the scientific method"; "learn to think for themselves"; "training in problem solving," etc., etc.

Under the category, *Retention and Learning Values,* there were 24 responses:

"Pupils learn more and retain more," 9; "pupils learn more," 5; "they remember more" (residue of learning greater), 5; "laboratory replaces abstractions with concrete experiences," 2; and "laboratory aids learning."

Seventeen respondents said that *the laboratory trains* observation or the power of observation, or that the pupil learns to observe more carefully.

Fourteen respondents gave various *pedagogical reasons* for the use of the laboratory such as:

"Active instead of passive participation"; "more senses stimulated through laboratory work"; "need contact with 'things'"; "using hands calls for thinking"; "child gets understandings and appreciations in handling materials," etc., etc.

Lastly, 17 reasons of a general nature were given, such as:

"Many worthwhile objectives gained through laboratory work"; "better grasp of science understanding"; "more nearly approaches life conditions" (we hope so); "better teacher-pupil relationships"; "certain outcomes obtained in no other way," etc., etc.

A few of the more complete statements follow:

"In many instances 'lab. work' carries more interest, gives a better basis for understandings, gives first-hand acquaintance with the scientific method. It is time-consuming and more expensive." "Nothing should ever displace individual laboratory work with children. We do need to give our pupils a part in planning their own experiments, however, and so get away from the slavish use of manuals and workbooks." "Pupils learn by doing and have more fun doing it." "Students need primary experience in science. They do not know how to observe, hence are unable to determine facts or generalize accurately." "It is interesting to students; it makes experience more vivid and lasting, and it makes possible real science projects." "Learning how to experiment is one of the fundamental parts of the scientific method. We set up the following purposes for the laboratory: (1) scientific method, (2) scientific activities, (3) discovering problems, (4) solving problems, (5) methods of getting information, (6) some beneficial skills." "I believe where possible that it is better for the individual to perform his own experiments under the teacher's guidance because of (1) greater student interest, (2) better opportunity for individual instruction, (3) closer contacts with teacher, (4) more knowledge acquired, (5) practice in laboratory techniques." "Used demonstration techniques last year and on a group of nearly the same level used laboratory work this year. On identical semester tests, scores were uniformly higher this year. Chemistry improved about 8 per cent, physics about 15 per cent." "Tried such a method (demonstration) in two of our three junior high schools. The students received much less usable material and the future work of the students was less satisfactory than from the school retaining the laboratory. This method, however, was from a functional approach based on community needs."

The reasons given for using the demonstration without laboratory were frequently based on necessity rather than choice. For example, the demonstration method:

"Saves time," 32; "must be used because classes are too large," 31; "saves money, or cost of equipment and materials," 26; "used because of inadequate equipment," 20; and "lack of facilities," 14.

The latter answers were given largely at the junior high school level. Altogether, 156 respondents gave material reasons for using the demonstration *in place of* laboratory work. Thirty respondents gave *reasons of age* for use of the demonstration. Such were:

"Children at junior high school level are too young to handle apparatus"; "too immature"; "danger from accidents"; "junior high school students gain more from demonstration"; "better results with junior high school pupils," etc., etc.

These findings agree with those of the writer obtained from ninth grade pupils in the DeWitt Clinton High School many years ago.[5]

Twenty-seven respondents gave *pedagogical reasons* for the use of the demonstration. The most used reasons were:

"Results of demonstration more accurate"; "demonstration quicker"; "better understood"; "more thought-provoking"; "more emphasis by teacher on important points"; "more effective in general science," etc., etc.

Fourteen respondents gave *psychological reasons,* the most used statements being:

"Understood better"; "learning by the laboratory method is so slow"; "teacher a better showman"; "children interested in demonstration," etc., etc.

It was evident that the majority of answers favoring the demonstration came from teachers at the junior high school level, although there were many at the senior level who condemned laboratory work as:

"Time-wasting"; "busy work"; "waste of time to teach techniques"; "only loss from demonstration is that pupils do not learn to handle equipment," and, most cogent of all, "demonstration allows time for questioning."

Several of the respondents gave their views rather fully. Some of these statements follow:

"Our belief is that science that is functional in the lives of the pupils is the only sort worth while. Most of this is concerned with outside living, and relatively little of the formal laboratory type." "Too frequently pupils do not know the purpose of their experiments; hence laboratory work is wasteful of time and materials because of faulty techniques and uncertainty on the part of the pupil." "We have moved in this direction to the extent of eliminating much waste of time as mere 'busy work'." "I would modify the work by encouraging group or cooperative laboratory work followed by pupil demonstration. I believe that occasionally the teacher should demonstrate for the good of the pupils. I believe that our former laboratory work was financially expensive and was also expensive from the standpoint of time on the part of the pupil." "Learning by the laboratory method is horribly slow. Even the best scientists made their fundamental discoveries years apart. Pupils will make a real mess unless they see demonstrations on the techniques before trying them themselves." etc., etc.

Many of the more thoughtful respondents realized the catch in the question and stated that *both* the laboratory and demonstration should be used. Some forty or more gave reasons why, stating that:

"One type should supplement the other"; "some kinds of work lend themselves to laboratory, some to demonstration"; "must have both for individual differences"; "there should be a combination of both."

A few respondents, however, reached the real roots of the problem of the use of the laboratory when they gave reasons such as those that follow:

"Individual laboratory work trains in laboratory techniques. High schools should train to solve everyday problems. This can be done as well or better without individual laboratory." "Partly so, but not entirely. Some individual work is necessary in order to help the student get a real sense of what laboratory procedure amounts to. More than that is not necessary." "I believe there is no question here. One type of work is a supplement of the other. Surely demonstration does not teach the same things that a student learns by doing it himself." "There has been a definite shift in the direction of making our science courses more functional and relating science materials to daily life problems." "Learning does not occur by the use of any one method. Purpose determines the method used," etc., etc.

There is a very evident swing in the direction of functional procedures, regardless of what method is to be used, and it is evident that thinking teachers are coming more and more to see that whatever is

[5] Hunter, George W. "The Problem of Method in Elementary Biology." *School Science and Mathematics,* June, 1927.

given or however it is given, the materials used must be functional in the lives of the pupils.

A careful perusal of many of the answers brings out the fact that science teachers are quite sure that the laboratory procedure should differ with maturity of the pupil as well as with his future life work. This fact has been brought out in many of the answers already given. But many are far from satisfied with their present laboratory work, and many state that they are changing to a different approach in which the student works out his own problematic situations and then attempts solution without the use of manuals or workbooks. Apparently the discussion method has entered the laboratory as an aid to reflective thinking. Not many papers show this trend, but it is there, nevertheless.

THE NON-COLLEGE GROUP

The last question to be discussed is the following: *"How are your courses adapted to the needs of the pupil who does not go to college and for whom the secondary school is the only preparation for living?"* Over 300 of the 600 odd respondents said that their courses were meeting the needs of the non-college student as well as of those who were preparing for college, while over 90 expressed dissatisfaction with conditions as they then existed in their schools. Several of those dissenting said that general science and biology were doing fairly well in meeting the needs of the non-college student but that both chemistry and physics were given as college preparatory courses. Ten respondents said that the question did not apply, as their schools were college preparatory schools, the number going to college ranging from 90 percent to 99 percent.

There were many comments on this situation, some of which follow:

"Texts still show college board influence"; "we are governed too much by standards set by accrediting institutions"; "we stress too much college prep., and not enough practical applications"; "a revision of the physics syllabus is the greatest need for New York State"; "one type of course is given for college entrance but only about 10 per cent go to college"; "need more differentiated courses," etc., etc.

The group of respondents who believed the secondary schools were meeting the needs of those who did not go to college gave many ways in which the problem was met. Most frequent was the statement that there were two or more courses given in the school, one for the college preparatory student, and the other for the non-college type. These latter courses were called "terminal," "general," or "the industrial group." More specifically respondents gave type of courses or emphasis placed on courses. For example, 33 respondents said they emphasized practical applications; 15 said such courses were more functional and related to daily life; 11 said that they tried to have their students understand, appreciate and learn to control their environment; 10 emphasized practical applications to everyday problems; 5 said applications to environmental adjustment were emphasized; 5 said they gave practical science with community applications; 5 said that they emphasized citizenship needs; 3, that they emphasized applications of scientific principles; 3, that they emphasized everyday experiments. In other words, the emphasis of all the 95 respondents was upon the practical and functional aspects of the science they taught.

To meet these practical and functional needs a large number of relatively new courses were offered. Of these, 25 were "consumer science"—or science given from the consumer angle; 20, senior science or science survey; 11, life science; 10, applied science; 10, descriptive physical science; 7, applied chemistry; 5, agriculture; 4, descriptive chemistry, while there were numerous scattering courses given, such as applied physics, practical physics, "everyday physics," household physics for girls, household chemistry, physiography, forestry, horticulture, home making, home

beautification, industrial science, industrial hygiene, chemistry for nurses, advanced general science, and "everyday science."

Other respondents gave still other ways of meeting the problem. Five schools gave courses in physics and chemistry at three different levels; three schools gave science courses at two different levels, while one school offered five different courses in chemistry, and another five different courses in science as "a preparation for living." Four schools say they offer vocational courses, and three schools call them "terminal courses." Several say that the college preparatory courses are given with more laboratory work than the non-college courses and, in general, statements are made that the non-college courses are more descriptive and less technical.

A few of the respondents state that they meet individual differences and take care of the differences between the college and non-college student by means of:

> "Ability grouping," "differentiated assignments," "minimum-maximum assignments," "elastic assignments," etc.

In order to adapt the work to the needs and abilities of the non-college group the following methods were used:

> "Preparation for living," or "adaptation to life situations," 20; "interests of pupils to develop projects or problems," 14; "objectives based on needs of pupils," 14; "applications to common experience or to the local community," 11; "let the pupil pick out his own problems," 5.

A few used reports or projects for non-college students and many teachers employed projects and visual aids. Several made use of leisure time activities such as hobbies, excursions, field trips, school or individual gardening projects and home applications of science, while 5 stressed the problem of learning to read newspaper science intelligently. In several instances there was evidence of the tie-up of science with the vocational problems of the community. Three stressed a "better attitude toward conservation," and 2 respondents stated that they made a "conscious effort to relate science to the lives of students as citizens and consumers." On the whole, the reasons given were good, and many of the statements were fully given. A few of these from widely different localities follow:

> "By means of projects and visual aids we 'vocationalize' the science subject matter." "We present interesting problems based on the things most people like to do and know more about in the course of modern living. Some of the units are concerned with automobiles, radios, electrical appliances, air conditioning, refrigeration, etc., etc." "We stress thinking and reasoning. Wherever possible we link up the subject with the life of the individual student." "Most of our girls work for a few years and then marry. We try to give them some fundamental facts, a respect for science and science programs, and some knowledge of themselves and where to go for help when it is needed." "We are attempting to make part of every science course terminal in nature." "By assisting him to understand the basic science facts he meets from day to day. A great deal of effort is expended in assisting him to read the newspaper intelligently."

These are only a few of the many excellent answers that might be quoted.

A number of the respondents taught in the junior high schools, and their answers were segregated and analyzed. Here it was evident that "general background," understanding and appreciation of the environment, health instruction, and the exploratory function were most used by teachers. Several stressed "attitudes," and several recognized "practical adaptation to the environment" as their major goals. This group was not concerned with the college preparatory student except incidentally.

> Several respondents placed their emphasis on "problem solving and problem finding," while others stressed "scientific attitudes." One respondent said, "We try to get pupils to apply principles to new situations; that takes care of both groups." Another stated that "we are constantly trying to bring immediate environmental factors into our classrooms so that the developed experimental base will provide direct transfer to life situations for those who do not go to college, and at the same time provide the 'raw materials' for the more abstract college courses." "If scientific methods, analysis and understanding of science problems is reached, I think all pupils will get along at college, even if they are not

specifically prepared for college." This last answer is reflected in the statements of several respondents who believe that "college preparation should be preparation for life." As one respondent puts it: "A course that does not accomplish this has no place in the secondary school curriculum."

Although the writer realizes that injustice may have been done to the many teachers whose carefully thought-out answers may not have been quoted, he believes that the above tabulations and excerpts represent fairly well the thinking and practices of a select number of science teachers from some 650 representative secondary schools of the United States. The writer prefers not to give his own impressions of these findings, but rather, since he has stated the case briefly and concisely, to leave the decisions of how well our science teachers are meeting the challenge of modern education to the readers of this article.

VISUAL INSTRUCTION IN THE TEACHING OF THE SECONDARY SCIENCES

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THE eye is of great importance in the art of learning. This universally accepted idea has prompted the visual educational movement from the kindergarten to the graduate school. The value of the picture in the learning process is expressed in an old Chinese proverb which says, "One picture is worth a thousand words."

Visual materials have been used by most progressive teachers for a long time. Abrams [1] says, "The acquisition of knowledge through the eye is not a new method. Visual instruction is essentially a very old process." Comenius, sometimes called the father of modern education, stressed their use during the eighteenth century. Stitt [2] says, "Comenius—one of the greatest of educational reformers — emphasized the value of pictures to illustrate the idea symbolized by the word, and set the real standard for visual instruction."

THE VALUE OF VISUAL INSTRUCTION

Visual instruction should be considered a sensory supplement in our teaching. Educators agree that it can be a valuable addition to the conventional courses of study. It is a great asset to all pupils, but more especially to the eye-minded ones. Shriner [3] says, "Some pupils are eye-minded. They must see the process by picture or the actuality." The old saying, "What the eye sees, the mind will remember," is especially applicable to the eye-minded pupils. Cox and Long [4] say that people have "greater ability to appreciate and assimilate experiences which they can see and examine visually than those experiences which they merely hear." In 1916 the Department of Science Instruction of the National Education Association created a committee on visual instruction. These science teachers said that in the future science instruction "shall include the realm of the eye as well as that of the ear." [5]

The term visual aid is rather comprehensive. It includes such things as motion pictures, strip films, slides, flat pictures, charts, graphs, specimens, and models. In

[1] A. W. Abrams. "Collection, Organization, and Circulation of Visual Aids to Instruction by State Bureaus." *N. E. A. Addresses and Proceedings,* 1916: 746.

[2] Edward W. Stitt. "The Importance of Visual Instruction." *N. E. A. Addresses and Proceedings,* 1916: 738.

[3] J. T. Shriner. "Motion Pictures in the Teaching of High School Science." *General Science Quarterly,* 11: 40, November, 1926.

[4] Philip W. L. Cox and Forrest E. Long. *Principles of Secondary Education.* D. C. Heath and Company, Boston, 1932. P. 417.

[5] Edward W. Stitt, *op. cit.* P. 738.

this survey the term is being confined to motion pictures, slides, and strip films.

The value of visual education is not a moot question. The Thirty-First Yearbook of the National Society for the Study of Education[6] contains this statement: "Motion pictures have a valuable place in science teaching. They can provide experiences as real to the pupil as are many of the demonstrations and laboratory exercises. Often they surpass the latter in variety, clarity, and pertinency."

REVIEW OF RESEARCH STUDIES

Many investigations have been made recently concerning the value of visual instruction in teaching secondary science. The most extensive one was conducted in 1928 by Ben D. Wood, Columbia University, and Frank N. Freeman, University of Chicago.[7] These investigators divided approximately 3,500 pupils, who were studying general science in the junior high school under forty-eight teachers in twelve cities from New York to California, into two smaller groups for instructional purposes. Motion pictures were used with the experimental group, but not with the control one; otherwise, as nearly as was possible, identical conditions were maintained with both groups. This study extended over a period of ten weeks. A battery of tests was given, with the result that the experimental group exceeded in each test by an average of 15 per cent. The participating teachers expressed a keen interest in the use of the films, and had the conviction that the use of motion pictures was very effective in securing important and desirable outcomes not measurable by the tests.

In 1930 the writer with the assistance of two other teachers conducted an experiment in the use of slides. Each teacher selected two general science classes based upon intelligence and previous grades, one of which was used as the control and the other one as the experimental group. The investigation was made while studying the unit on astronomy for a period of three and one-half weeks. The control groups were taught similarly to the experimental ones, except in the latter case slides were used as a preview of the unit and again as a summary. The experimental groups exceeded the control groups on a comprehensive test given at the end of the study which is shown in Table I.

TABLE I

MEDIAN SCORES BY CONTROL AND EXPERIMENTAL GROUPS IN SCIENCE

Teacher	Control Group	Experimental Group
1	71	79
2	71	84
3	86.5	87
Average	76.2	80.3

Stackhouse reports two experimental studies with the Keystone General Science Units for two semesters. He says:

> There was a marked increase in the interest factor, and that the Units had definite value as supplementary material. . . . It was found that both the high and the low experimental groups surpassed the corresponding control groups in achievement scores. The slides seemed to be of greatest help to the low, or slow moving group.[8]

A carefully worked out experiment regarding the value of visual aids was performed by Wyman.[9] He had two full classes of ninth-grade general science of approximately equal ability. With the experimental group he used various types of visual aids such as movies, slides, charts, and models. The units on air, heat, and water were included in the investigation. The experimental group exceeded the con-

[6] National Society for the Study of Education. *A Program for Teaching Science.* Thirty-First Yearbook, Part I. Public School Publishing Company, Bloomington, Illinois, 1932. P. 294.

[7] Ben D. Wood and Frank N. Freeman. *Motion Pictures in the Classroom.* Houghton Mifflin Company, Boston, 1929. Pp. 4–215.

[8] J. M. Stackhouse. "Why Visual Materials Appeal in Science." *Education,* 56: 422–23, March, 1936.

[9] Carl E. Wyman. "Visual Aids—of What Worth?" *Science Education,* 16: 291–96, April, 1932.

trol group in each one of the three units studied.

Sound films are comparatively new as a method of instruction in the classroom. In these few years research has demonstrated their efficiency as a teaching medium. One of these studies was made by the Harvard Graduate School of Education and financed by the Carnegie Foundation for the Advancement of Teaching.[10] This investigation included ninth-grade science in three suburbs of Boston. The 2,860 pupils were divided into three very similar groups—uninstructed, control, and experimental. The "Control" and "Film" groups were taught for six weeks. Motion pictures were included in the instruction of the latter group, but not the former group. Two tests were given, one of which immediately followed the experiment and the other one was administered three months later. On the first test the experimental group showed a superiority of 20.5 per cent over the control group. On the second test the results were more significant as the difference increased to 38.5 per cent.

A very careful investigation of the effectiveness of the sound film in teaching elementary science was made by Arnspiger.[11] This study included 950 pupils in thirty-two science classes distributed among five cities in three states. The pupils of the experimental group were presented with three showings of each talking picture during the regular class period. The results of this study showed that pupils using sound films in science learned 26 per cent more than the students taught by the ordinary classroom methods.

Einbecker found that silent films could be made as effective as sound films. He conducted a series of experiments to determine the relative value of talking and silent pictures. The groups were composed of general science and physics pupils, who were classified according to mental ability. The presentation of the silent films were accompanied by oral comments of the teacher. Concerning the results of the investigation he says:

> This study indicates that, so far as instructional values in science are involved, the printed caption accompanied by the oral comments of the teacher forms visual images and oral stimuli which are at least as effective as the impressions formed by the talking pictures.[12]

SOME RECOMMENDATIONS

Adequate explanations of the difficult processes should be made during the showing of the silent film. Hunter[13] says, "Teachers should remember that at any time they are at liberty to add the auditory to the visual stimulus." Running comments concerning the film are most useful to the pupils. Questions on the part of the teacher may serve the purpose of certain explanations.

Apparatus for teaching science on the secondary level is expensive, so much so that comparatively few schools have sufficient funds to purchase the needed equipment. Moving pictures have proved to be an excellent supplement to demonstration and laboratory procedure, but could they not serve in many instances as substitutes for equipment on the secondary level? In speaking of the changing trends in the teaching of science in the first twelve grades Frank[14] says, "It is predicted that if this twelve-year program is found effective, we shall find that at least 40 per cent of our high school science can be successfully, and much more cheaply, taught by means of moving pictures." Regarding

[10] Philip J. Rulon. *The Sound Motion Picture in Science Teaching.* Harvard University Press, Cambridge, Massachusetts, 1933. Pp. IX, 17–89.

[11] V. C. Arnspiger. "The Relative Effectiveness of the Sound Motion Picture in Teaching Elementary Science and Music." *Education,* 53: 332–35, February, 1933.

[12] William F. Einbecker. "Comparison of Verbal Accompaniments to Films." *School Review,* 41: 185–92, March, 1933.

[13] George W. Hunter. *Science Teaching.* American Book Company, New York, 1934. P. 304.

[14] J. O. Frank. *The Teaching of High School Chemistry.* J. O. Frank and Sons, Oshkosh, Wisconsin, 1932. P. 61.

this idea the following quotation is very significant:

> Certainly, visual aids can improve tremendously the teaching of science in those cases, altogether too many, where equipment and facilities are either nonexistent or too meagerly provided. But even teachers working in superbly equipped science classrooms cannot afford to ignore some of the recent films.[15]

The present tendency is definitely away from indiscriminate showing of motion pictures. The idea is to synchronize the visual material with lesson plans and not simply add it to them as different material. Hunter[16] comments as follows: "The visual aids must come as supplementary to the teaching if they are to be of real value and must be definitely synchronized with the problem in hand."

EQUIPMENT FOR VISUAL INSTRUCTION

Administrators, supervisors, and teachers in secondary schools are becoming more cognizant of the value of visual instruction, but there is ample room for improvement. In 1936 a national survey of visual instruction was completed by the United States Office of Education and the American Council on Education.[17] It covered visual and audio aids in the elementary and secondary schools of the United States. This investigation revealed that the schools own more than 34,000 projectors of which 9,304 were silent and 793 were sound-motion picture projectors. Further, science teachers use motion pictures more than do the teachers of the other subject fields, in fact 22 per cent of all the motion pictures shown in the schools were used in science classes. Dale[18] says, "The motion picture has a unique contribution to make in the field of sciences. Indeed, the science films are among the most widely and most effectively used films in the high school."

The writer made a sampling study of the teaching of general science in the secondary schools of the United States with special emphasis on Kentucky. The United States was divided into five geographical divisions and two states were selected from each division. Three schools from each of the ten states were studied, one of which was a secondary school in a large city, the second one a high school in a city of medium size, and the third, a secondary school in a rural area. Similarly, Kentucky was surveyed. A total of forty-five schools was included in the study.

The results of the study made by the writer regarding picture projectors may be found in Table II. Thirty per cent of the schools investigated own 16-millimeter silent motion picture projectors, but only 6.6 per cent have 35-millimeter ones. Only 15.5 per cent of the schools own 16-millimeter sound projectors, and 4.4 per cent have 35-millimeter ones. The larger the school the greater is the probability of its having a motion picture projector. Approximately one-fifth of the schools own strip film and opaque pro-

[15] Editorial. "The Science Teacher and Visual Aids to Instruction." *The Science Classroom*, 11:1, April, 1932.

[16] George W. Hunter, *op. cit.* P. 319.

[17] Cline M. Koon and Allen W. Noble. *National Visual Education Directory*. American Council on Education, Washington, D. C., 1936. P. 9.

[18] Edgar Dale. "Motion Pictures in Education." *The Peabody Reflector and the Alumni News*, 12:53, February, 1939.

TABLE II

THE PERCENTAGE OF SCHOOLS INCLUDED IN THIS SURVEY THAT OWN PICTURE PROJECTORS

Classification of Schools	Projectors						
	16 mm.		35 mm.				
	Silent	Sound	Silent	Sound	Strip Film	Opaque	Slide
Rural or Small Town...	16.6	0	0	0	13.3	26.6	33.3
Medium City	33.3	20	6.6	0	26.6	20	66.6
Large City	40	26.6	13.3	13.3	13.3	20	33.3

jectors, but almost one-half of them have slide projectors. There is a fairly equal distribution of strip film, opaque, and slide projectors among the small, average, and large-sized schools.

This survey reveals that it is customary to rent science films. About one-fourth of these schools use free films, and a much smaller fraction of them own films. The percentage of rented, borrowed and purchased slides is very similar in the various sized schools. The compilation of these data is found in Table III.

Visual instruction has proved to be very effective in the teaching of science in secondary schools. The pupils who are taught by the use of slides or motion pictures obtain a more thorough mastery of the content, and they retain it longer when judged by objective tests. Of the schools included in this study, 30 per cent own 16-millimeter silent motion picture projectors and 15.5 per cent have 16-millimeter sound projectors; approximately 10 per cent possess 35-millimeter projectors; and 44.4 per cent have slide projectors. Teachers of science make greater use of visual instruction than do the teachers of the other secondary school subjects.

TABLE III

THE SOURCE OF FILMS AND SLIDES FOR GENERAL SCIENCE AMONG THE SCHOOLS INVESTIGATED EXPRESSED IN PER CENT *

Classification of Schools	Films			Slides		
	Rented	Free	Bought	Rented	Borrowed	Bought
Rural or Small Town	26.6	20	0	26.6	13.3	20
Medium City	40	33.3	20	40	33.3	26.6
Large City	26.6	20	13.3	0	13.3	20

* Three schools indicated that they made some of their slides and films.

TESTING AS A MEANS OF IMPROVING INSTRUCTION

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PROMINENT among the reasons commonly given by teachers for administering tests are these: to reveal faulty learning and poor teaching; to stimulate the pupils to greater efforts; to provide a basis for the monthly, or the term, marks; to provide objective evidence with respect to the achievement of the pupils; and to provide an effective means of reteaching important aspects of the work. Of these the last, the use of tests for teaching purposes, is perhaps least frequently stressed; yet it is by far the most important.

For several reasons it is good practice to administer tests frequently. Under a program of frequent testing, pupils lose much of the fear of tests which, with some pupils at least, tends to reduce the achievement scores. Frequent testing, moreover, provides a means of checking on the mastery of essentials at the optimal times for remedying ineffective teaching or faulty learning. The tests need not be long ones; several short-answer items administered a few at a time at frequent intervals may be combined into one unit for marking purposes, and can be considered, together with longer tests administered once or twice during a "marking period," in evaluating pupil progress both from day to day and at the completion of a big unit.

The testing program in any course should consist neither of short-answer tests only, nor of essay-type tests exclusively.

A well-balanced testing program employs a combination of short-answer and essay-type items, because each type possesses substantial advantages not possessed by the other. The short-answer test is superior to the essay type in that it affords a means of "covering" several times as many aspects of a unit; because it is more reliable (more likely to give the same score again under the similar conditions); because it is more valid (more likely actually to test what it is intended to test); because it entails less fatigue in making the responses and in marking them; and because it affords less chance for "bluffing" and "stalling." The essay type is superior to the short-answer tests in that it provides the pupils with an opportunity to secure important training in organizing materials and in expressing themselves effectively in writing; and because it affords less opportunity for cheating.

Many teachers administer fewer tests than they would like to give, because of the enormous amount of time and energy they are accustomed to consume in correcting the papers. The legitimate question therefore immediately arises: "Is there any way in which tests can be corrected that will reduce the amount of the teacher's time and energy which needs to be expended in his out-of-class hours and which at the same time will give the pupils the advantages which they should derive from the tests?" The answer, in so far as short-answer tests are concerned, is emphatically, "Yes."

Some years ago, extensive and careful research was conducted in classes of high school science at the University of Michigan, and later at the University of Minnesota, to determine which of four common practices in evaluating new type, or short-answer tests was most effective for *teaching* purposes. Under Method I, the teacher collected the papers and carefully wrote in all the corrections. In a subsequent class period, the papers were returned to the pupils and the teacher conducted a discussion of the items one by one. Under Method II, the teacher collected the papers and carefully wrote in all the corrections, as under Method I, but when the papers were subsequently returned to their owners, the class discussion was limited to such questions as the pupils asked in response to the teacher's statement: "I have carefully corrected all the errors on your papers. Look over your paper carefully and ask any question you may wish to about any of the items or the corrections." With Method III, the correction was made entirely in class; as the teacher gave the correct responses, the pupils merely checked the items having incorrect responses, on their own or on somebody else's paper. Free discussion was encouraged. Under Method IV, the teacher collected the test papers and checked the items that were incorrectly answered, but wrote in no corrections. The papers were later returned to their owners and the items were discussed one by one.

Subsequently, with all four methods the original tests were again administered to the pupils in order to determine the amounts of learning as indicated by higher scores that had resulted from the four different uses of the tests for teaching purposes.

The results showed that Method III, that by which the pupils merely checked the incorrect responses on their own or on another pupil's paper as the items were discussed in class, was found to be most effective. Method II, in which the teacher wrote in all the corrections but in which only those items were subsequently discussed about which the pupils asked questions, was found to be consistently least profitable as a means of improving the pupils' knowledge of the materials covered.

The implications which seem justified from these research investigations are these: When short-answer tests are used for purposes of reteaching important aspects of a unit, the one of the four com-

mon correctional procedures investigated (Method III) that demands the least of the teacher's energy and time, namely, that under which the pupils merely check the incorrect items on their own or on other pupils' papers while the items are being discussed one by one, is the most profitable. The method (Method II) which does not provide an item-by-item discussion of the test papers is of considerably less value than any one of the three methods in which such discussion is employed.

These investigational results seem to justify this important and perhaps somewhat startling conclusion, which during the several years since the investigation was reported has not been challenged, namely, that the laborious method by which the teacher corrects all the errors on every paper is not only prohibitively expensive of his time and energy, but, what is even more important, it is wholly unjustified in so far as subsequent benefit to the pupil is concerned. When short-answer tests are used, therefore, the teacher would more profitably spend his evenings in recreation or in professional reading than in "going over" the pupil's test papers. He will benefit the pupils more by administering the test in the first half of the period and discussing it with them item by item while they check the incorrect responses, during the latter half. These discussions, however, apply only to short-answer test items; no satisfactory method has yet been announced by which pupils can effectively correct essay-type questions.

The question immediately arises in connection with the procedure advocated on the basis of these research results: "Is it not too much to expect that the pupils will conscientiously accept the responsibility of checking all the incorrect responses on their own or on other pupils' test papers?" In a series of investigations designed to seek the answer to this question it was found that the incorrect checking of items, resulting from cheating or carelessness, was maintained at an acceptably low level by a simple safeguard. The teacher at the time the papers were to be discussed and checked in class, provided colored pencils for the checking and then announced, "Be careful in checking these items, because I shall examine some, but not all, of the papers afterwards; and any errors made in checking will be counted against the person who did the checking. Please sign your name on the paper you are checking." In one experiment conducted in a large city, the pupils were first allowed to check the incorrect responses without the teacher's cautioning them to be accurate in their corrections. When the teacher subsequently checked the accuracy of the markings he discovered in some classes a percentage of incorrectly checked or of altered items as high as 75 percent; when, however, the admonition just stated was given to the same classes in subsequent tests, the percentage of incorrectly marked items ranged from about 6 percent to about 1½ percent. It seems doubtful whether teachers themselves could have checked the same papers with a greater degree of accuracy than these latter figures indicate.

BIOLOGY AND HUMAN LIFE

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A NUMBER of years ago the late Dr. Henry Kelly developed at Fieldston School a course known as Biology and Human Life. This course was offered to twelfth-grade girls who were interested in preparation pointing toward work in the areas of home economics and child care. The subject matter consisted of material from the fields of evolution, anthropology, psychology, embryology, genetics, and geology—material which would be helpful in making youngsters consider their own development more objectively. *The Science of Life* by Wells, Huxley, and Wells was the textbook. Most of the laboratory work was concerned with genetics and embryology. Special speakers were brought in to the course at appropriate times. There were many field trips both to laboratories and to social agencies. The class met for six periods each week. During the course of a year, the following topics were studied:

Life at Its Lowest Terms
Man's Place in Nature
Life's Struggles Through Time
The Transmission of Life
The Physical Development of the Individual
Fundamental Adjustments to Life
The Mechanism of Adjustment and Response
The Concept of Evolution
Adjustments to the Social Environment
Biology and Human Welfare: Some Problems of Today and Tomorrow

It soon became apparent that the course was a valuable experience for the girls who took the work—so valuable, in fact, that it should be open to many more students. Some five years ago the science teachers decided to bring more of the material from this course into the general biology course which is offered to tenth- and eleventh-grade students. Consequently, a unit was developed which was given four periods a week for four to six weeks on changes and adjustments during the human life span. The changes were considered in chronological order: infancy, childhood, prepubescence, pubescence, post-pubescence, adulthood, senescence, and death.

Sometimes the work was started by asking the classes to write individual papers on topics such as: What Shirley Temple (or some other well-known child) will be like when she grows up. Then they were asked to write about themselves and what they thought they would be like when they grew up. It was interesting to observe that, although the students recognized that Shirley Temple's adult life would be affected by her background and experiences, they rarely seemed aware that their own futures would be determined by similar factors.

After three years of experimentation with this material and the unit approach to it through a fixed period, it seemed worth while to try instead a plan whereby one biology period a week during the entire year was devoted to the study of the life-span material. This procedure has been followed during the past two years, and has been found desirable from the points of view of schedule, of the developing maturity of the students as the year goes along, and of availability of demonstration material.

Now work in this area is begun with a discussion of the question: Why is it of value for high-school people to study development throughout the human life span? Out of this discussion and papers written in answer to this question comes a statement of student and teacher objectives for the work to be undertaken. This year these objectives are as follows:

1. If we know more about the changes occurring during the human life span it will help us in understanding other people and also ourselves.

2. We students will be living during a period when there will be more old people; we should know more about them.
3. Most of us hope to have children. If we know more about the development of children maybe we can be good parents.
4. People are dependent on each other for many things; therefore we would like to know more about our interdependence.
5. To be different in many ways is normal; we would like to get scientific facts about this.
6. Many people have not been able to tell us about the "facts of life"; we ought to get correct information.

After setting the objectives the summary of the last White House Conference Report was read. Discussion of this report leads to the conclusion that in addition to knowing about their own development, people in a democratic nation have a social responsibility to make the development of every child important. A brief statement will indicate the way in which the study proceeds from this point.

When prenatal development is being considered, the classes read and discuss *Biography of the Unborn* by Margaret Shea Gilbert. Human fetuses are available as demonstration material, as are charts and diagrams obtained from organizations dealing with prenatal care.

While studying the period of infancy, the classes first consider material on infant mortality obtained from the Federal Bureau of Vital Statistics and the Childrens Bureau. They then proceed to a discussion of basic adjustments which the infant must make. Young children are brought into the classroom. After observing them for ten or fifteen minutes, the students have an opportunity to ask questions of the mother. These are very fruitful discussions in emphasizing for the students the differences between individuals. They also emphasize the importance of understanding biological development in order to understand behavior of the infant or pre-school child.

The biology classes visit the elementary school during their study of childhood, and elementary school teachers answer questions which the students have about adjustments during the elementary school period. Similarly, the teachers of the junior high school come to the biology classes to answer questions about the educational program for children in junior high school. The biology students find their study of the prepubescent period important, for they begin to understand some of the endocrine changes that go on, and are relieved to know that there is very little abnormal about their own growth.

Changes during pubescence and postpubescence as well as adulthood are discussed as biological phenomena. Of course, the students are most interested in what might be called the psychology of personality during these discussions. Frequent questions in class are of the type: "Why do I do this or that?" "Why do my parents do this or that?" During study of the adult a good deal of time is given to problems of intellectual development, vocational choice, and diseases of this period. In studying senescence, diseases of old age are considered and much attention is given to the problem of understanding old people. Consideration of the biological changes that accompany death concluded the work of the course last year. If there is time this year, some material from anthropology will be included in order to develop an understanding of some of the conflicts which exist in our culture in regard to the care and management of people's lives.

A person looking over the high spots which have been touched on might well ask, "Is this biology?" But another question might equally well be asked: "Does the science teacher have a responsibility to use material from his area of knowledge which will help people live better lives?" Is that biology?

STUDYING THE HUMAN BODY

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The study of the human body is a study of relationships. Our conception of the human body is derived from our conceptions of the nature of matter-energy, the nature of the universe, the nature of the world, and the nature of living things. The human body, in part, is a product of the twentieth century. Man's tools and modes of production, his methods of distribution, his patterns of consumption, and the controls exercised over him are changing his characteristics and his culture. The culture which impinges most often on the lives of the boys and girls we are teaching is the culture of the twentieth century—twentieth century production, twentieth century consumption, twentieth century controls, twentieth century conceptions of the nature of living things. Within these areas are relationships which students must understand before they can apply their knowledge of the human body in the world in which they live. To study the human body apart from these great areas of living in the twentieth century—to study it apart from the interrelated problems and conceptions of the twentieth century—is to study the human body in a sterile medium. To omit emphasis of the great social and natural forces of the twentieth century in a study of the human body is to make education a milk-and-water proposition while the important forces which mold behavior are neglected. These reasons formed the basis for the organization of the unit, *The Human Body*, a "life problem" unit in the general education program in the College High School at Greeley, Colorado. The unit consists of a study of the systems of the human body in relation to life in the twentieth century. Each system, the circulatory, dermal, digestive, reproductive, and skeletal—is taught so as to emphasize the impacts of social and natural forces upon it. This article reports the organization and learning activities used in studying the dermal system. The same pattern of organization was used in studying the other systems, but different learning activities were used.

During an overview lesson the students organized the study of the skin about four problems:

What is the nature of the skin?
What is the function of the skin?
What effect has life in the twentieth century on the skin?
What application of our knowledge can be made in our everyday living?

The first and second problems were studied together. Activities consisted of class discussions, reading, teacher presentation of materials; and the study of charts, tables, and diagrams. During the study of these two problems many specific questions were answered, among them the following:

What is one square centimeter of skin like?
What is leather?
What is the effect of burning the skin?
What is the effect of sunlight on the skin? of massage?
What is the function of the muscles in the skin?
How does hair grow?
What are fingernails and toe nails?
What are fingerprints?

The third problem was studied in small groups. Each member of the class joined a group of students; each group selected one learning activity. The learning activities were as follows:

Analysis of magazine advertisements of preparations for use on the skin to determine the number of advertisements, the kinds of products advertised, their uses, and the claims made for them.

Analysis of *Consumer Research* reports on advertised skin preparations to compare them with the advertisements.

Interview with the school nurse for answers to such questions as:

What is an inexpensive and simple method of care for the skin?
How does diet affect the skin?
How do cosmetics affect the skin?
What skin diseases are contagious?
What causes skin disorders?

Interview with the owner of a beauty parlor for answers to such questions as:
What treatments do you recommend for the skin and the hair?
What kinds of treatments do people ask for most often?
What kinds of equipment do you use?
What is the purpose of a facial?

Checking articles in current periodicals such as *Time, Science News Letter* and *Hygeia* with the information obtained from textbooks, the school nurse, and the beauty parlor owner. The articles were about such subjects as:
New treatments for burns.
Athlete's foot.
Care of the skin.
Dandruff.

Analysis of census reports of 1919, 1929, 1939 to determine the value and place of cosmetic manufacture as reflected by the value of the products; value of materials, supplies and containers; value added by manufacture; the number of establishments; and the amount of fuel used to produce skin preparations.

Estimating the stock of skin preparations in the drug stores of the community to indicate the consumption of skin preparations.

The information obtained was presented to the class by each group. Maps, charts, tables, and pictographs were used. After each report was given, the information was discussed in terms of its application in the lives of the members of the class. Thus the fourth problem was attacked—namely, what application of our knowledge can be made in our everyday living?

The following important relationships were discussed by the students:

1. Twentieth century modes of production and distribution, and the patterns of consumption of skin preparations help determine the kind of care the skin receives. These preparations are affecting daily the skins of high school students. The industry has become so large, so many kinds of preparations are available, and the effects on the skin are so direct and evident that knowledge of the use and effect on the skin is essential for high school students.

2. The selection of preparations and the care of the skin are controlled by many forces: manufacturers, consumer research reports, the medical and nursing professions, beauty parlors, current periodical articles, and the knowledge individuals possess. These controls have become a part of the heritage of the American public. Each high school student himself should be a controlling force. This is possible only through an understanding of the nature and function of the skin, and of its effect on the rest of the body. It is necessary to check lay opinions with those of the nursing or medical profession. All skin preparations are not equally good for every skin. Some are harmful. Advertisements are not always reliable sources of information. Many preparations are of no harm or value to the skin. A healthy skin can be maintained without great cost to the individual.

3. Scientific research is providing new drugs and treatments and cures for skin disorders. Twentieth century research is changing our ideas of how to maintain a healthy skin and how to treat a diseased one.

The final learning activity in the study of the skin was a test in which the items were organized according to the specific objectives of the course. The teacher and the student together evaluated the student's work, using the terms "outstanding," "satisfactory," "needs improvement," "has made progress but needs further improvement," or "unsatisfactory."

The objectives included such general behaviors as these:

He participates effectively in class discussion.
His work is neat.
He uses the library effectively.
He is considerate of the rights and privileges of others.

They included also such specific actions as the following:

He expresses scientific ideas correctly.
He has increased his knowledge about the human body.

He explains the causes of poor health.
He explains why certain parts of the body require a certain kind of care.
He applies his knowledge of the human body to everyday life.

The care of the skin is but one aspect of hygienic living in the twentieth century world; but in this area are reflected the complicated, interrelated problems of twentieth century living. The application of knowledge in everyday living implies application to the areas of production, distribution, consumption, and control, as well as to proper skin care. Knowledge, the ability to seek expert advice, and application of what we know are essential if we are not to be controlled by quacks, superstition, and misconception.

THE NEW YORK CONFERENCE OF N.A.R.S.T.

THE National Association for Research in Science Teaching is planning a regional conference to be held at Teachers College, Columbia University, New York City, on March 18. It appears as this issue goes to press that the National Council on Elementary Science will join in the conference.

It is too early to report specifically concerning the program under consideration. However, the Program Committee is planning reports on new research in the field of science teaching for the morning meeting. National leaders in science education will be invited to report on recent developments in research in elementary and secondary education. An afternoon session may be devoted to Science in Post-War Planning. Workers in science education at all levels are welcome to attend both meetings.

Much interest has been manifested in this regional meeting and it appears likely that there will be many in attendance from the Mid-West, New England and the South.

The officers of the N.A.R.S.T. are Dr. Florence Billig, Wayne University, Detroit, Michigan, President; Professor Charles Pieper, New York University, New York, Vice-President; and Mr. Ellsworth Obourn, The John Burroughs School, Clayton, Missouri, Secretary-Treasurer.

In connection with the conference the Board of Stockholders of Science Education, Incorporated, will hold its annual business meeting, at which time it will continue planning the reorganization of this journal.

It is suggested that those planning to remain in New York overnight make their hotel reservations at their earliest convenience.

NINTH GRADERS' CONCEPTS OF ENERGY

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IT may be safely premised that an understanding of fundamental physical concepts is necessary to intelligent consideration of the problems of the contemporary world. Before thinking can be clear, concepts must have real meaning, for concepts are the tools of thought. The study of science materials should not only result in new concepts, but in altered old ones. For teaching to be effectually directed toward clarifying thinking, it appears necessary to know what steps there are in the gradual process by which hazy ideas become scientific concepts.

A preliminary attempt has been made to explore this process, following some of the procedures used by Black.[1] Fourteen boys and thirty-two girls, ninth-grade general science students, responded in writing to questions about energy on four separate occasions during a period of four months. At the time of their last response, their chronological ages ranged from 13.7 years to 16.4 years. Their scholastic aptitude scores ranged from 84 to 120 (Otis Quick-Scoring Mental Ability Tests, Gamma Test, Form A).

The boys and girls had studied units concerned with air pressure, fire, heating and ventilation, weather and climate, water supply, and hydrostatics, at the time when they were first asked to write what the word *energy* meant to them. After the children had studied the topics of light, sound, magnetism, and electricity, they were asked for the second time to tell the meaning of the word *energy*. On neither of these occasions did there appear to be any compulsion to write the "correct" meaning, the one that the teacher "wanted." The children were interested in comparing what a word meant to them with what it meant to other members of their class. The word *energy* was only one of several words which were discussed.

At the time of the first response, fourteen children gave *power, strength,* or *force* as the meaning of energy, without attempting any explanation; twenty-one considered energy only as an attribute of living things, with pep or ambition as the prevailing notion; and eleven knew that energy referred to the inanimate as well as to the animate world, making statements such as this one: "Energy makes people and cars, etc., move."

When the children responded to the second request, the word *energy* still meant much the same as it had on the first occasion. In none of the responses was electricity mentioned as a form of energy; this in spite of the fact that during the preceding weeks, when a unit on electricity was being studied, the teacher consistently used the phrase *electrical energy* instead of the word *electricity*. During this unit, too, the pupils had performed demonstrations to show the transformation of electrical energy to other forms and that of mechanical and chemical energy to electricity. They had participated in discussions in which the source of electrical energy was shown to be the sun.

The children's third response was obtained under somewhat different conditions. The unit following electricity was one on simple machines. At its close a test was administered in which one item was: Define friction, gravity, work, inertia, and energy. Facing a test, the children "played safe." They gave, almost unanimously, variants of

[1] Black, Oswald F. *The Development of Certain Concepts of Physics in High School Students.* "Die Weste," Potschefstroom, South Africa, no date.

the text-book definition: Energy is the capacity to do work.

This was much the same sort of situation as that in which Black obtained evidence which led him to conclude that general science and physics students can acquire scientific concepts. And if correct definitions are evidence of the formation of scientific concepts, many of the subjects of this study had a scientific concept of energy at the time of their third response.

But they lost it! Less than a month later, after a study of the use of metals and machines for power and transportation, the students were given an objective test which was too short to require all the time allotted to it. The teacher suggested that the children use their extra time to write ten or twelve lines on the topic: "Energy in Daily Life." In the paragraphs they wrote, twenty-six children referred only to the energy of foods; twenty made some reference to other forms of energy while discussing chiefly muscular energy. Yet this sort of energy had not been mentioned in class for seven months, and then only casually for a part of one period.

Two conclusions may be tentatively drawn from a study of the children's responses. First, the word *energy* refers to an entity apparently much too vague to be used as a pattern of learning material for ninth-grade children of average ability. Second, the fact that most children were limited to a conception of energy as muscular energy suggests that a rearrangement of the usual general science course of study would be advisable. It might be well to study the available energy of foods first, leading to the development of a generalization to the effect that physiological processes are made possible by the availability of chemical energy, and to a recognition that the sun is the source of the energy of foods. But the sun is not only the source of the energy of foods, it is also the source of the energy man obtains from fuels and of the energy of running water. The ideas of the transformation of the energy of the sun into forms readily available to man, and of man's own ability to change energy from one form to another may then begin to have meaning for ninth graders.

A CHEMISTRY CLASS VISITS A FOUNDRY

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ON November 17, 1943, a chemistry class in the Olney High School visited the foundry located across the street from the school. The double period of ninety minutes for laboratory and the close proximity of the foundry to the school provided enough time to make two trips through the foundry, half the class going at one time. The teacher of the class accompanied one half of the class and the assistant the other so that neither group was left unsupervised at any time. No time was lost between trips, for the second group was assembled in the foundry's office when the first group came out.

While the one group was going through the foundry the other group remained in the classroom and discussed the layout of the plant. The different units were identified as the pattern shop, the cupola section, the cleaning shop, and the storage sheds.

PREPARATION OF THE CLASS FOR THE TRIP

The class had been studying metals for five or six weeks, ending with the study of iron and steel. About two weeks had been spent on the study of iron: the ores of iron; the different forms of iron; the reactions involved in the making of pig iron, Bessemer and open hearth steel, and wrought

iron; alloy steels; and compounds of iron.

Before taking the trip, each member of the class was given the following directions in mimeographed form:

Your Trip Through the Olney Foundry

You are guests of the Olney Foundry at a time when labor is scarce and production demands are heavy. Show your appreciation of this privilege: (1) By showing a keen interest in the work going on and the information your guide is giving you. He knows more about a foundry than could ever be learned from a book. Ask pertinent questions. (2) By instantly obeying directions and warnings given you by your guide. There is danger in not looking where you are going; we do not want to interfere with war work.

Some points to note:

1. The raw materials brought to the foundry.

   How are these materials transported?
   From where do they come?
   How is each of these materials used?
   Must the materials follow specifications?
   What waste materials are formed? What is done with these?

2. The kinds of work done in the foundry. (Does Olney High School provide training for any of these jobs?)

   What is the pattern shop?
   What are the cupolas?
   Where are the casts made?
   Are any chemists employed in the plant?
   What is the cause of the noise that reaches our classroom?
   What are some of the jobs that are not actual foundry work?

3. The working conditions.

   What kind of spirit pervades the shop? Do the workmen seem to like their jobs?
   Note races and nationalities of the workers.
   For what jobs are women employed?
   Is the work unnecessarily dangerous?
   What provision is made in case of accident?
   What purpose is served by the sodium chloride tablets available in containers on the wall?

MATERIALS OBSERVED DURING THE TRIP

1. Pig iron. Different piles were seen, each pile consisting of pig iron of different composition. The composition depended upon the location from which the iron came and upon the management of the furnace during its preparation.

2. Scrap iron. The need of scrap impressed the pupils with the importance of the drives in which they participated.

3. Limestone.

4. Sand. The class learned the importance of uniform size and the difference between molding sand that requires no treatment and sand that must be treated before use.

5. Mica schist. This is used to glaze and mend the lining of the cupola.

OPERATIONS SEEN IN A TRIP THROUGH A FOUNDRY

1. Pattern making. The Olney High School gives a course in pattern making; consequently this operation was especially interesting to some of the boys.

2. Making the molds for pouring the iron.

3. Molds being set out in the cupola room. Some molds had had the iron poured into them. In these a small flame could be seen. The pupils learned that the flame was burning hydrogen formed by the action of the hot iron on the steam in the sand.

4. Loading the cupola. The visiting students were permitted to climb the stairs to the top of the cupola. They watched the men bring loads of coke, limestone, pig iron, scrap iron, and occasionally some briquettes. The part played by each of these materials was explained to the group.

5. Heating the ladles preparatory to the pour.

6. Pouring the molten iron into the molds. Of course this was the most spectacular part of the trip.

7. Cranes moving the large ladles of molten iron and other heavy objects.

8. Annealing pit.

9. Trimming the castings.

10. Chemical analysis of raw materials and products.

EVALUATION OF THE TRIP

Perhaps the most significant result of the trip—at least from the teacher's point of view—was the feeling the pupils expressed in one way or another that chemistry is not confined to the class room. To hear a man dressed in ordinary working clothes freely speak of oxidation and reduction, graphitic carbon, flux and slag, moved chemistry from the realm of mental gymnastics to the everyday world. It was evident many times that the pupils were surprised to hear someone talk the same language as their teacher. It seems hardly necessary to mention the value of having the words of the book become real objects: words such as pig iron, limestone, coke, cupola, tuyeres, charge, and flux.

The importance of laboratory technique was brought out by our visit to the foundry laboratory. The members felt proud to be able to recognize various types of apparatus. Their own task of reporting experiments took on meaning as they realized that in the foundry, too, experiments are performed, results recorded, and conclusions drawn from observations.

Several members of the class recognized former Olney High School pupils working in the foundry—not in white collar jobs. They were eager to be recognized by these boys and talk about them in class. One boy was an assistant to the guide and went with him on the tour for instruction. This, together with a constant reference to the fact that the men know just when to do what, emphasized the importance of experience in a job.

The contribution made by the individual toward a common product was not overlooked. Although the class visited different shops the pupils recognized the common goal and the responsibility of each worker for the achievement of a perfect product.

Interest in the working conditions was particularly keen with these students because in their hygiene classes they were studying industrial hygiene. The dirt about the place and in the air led them to ask questions concerning the chance of tuberculosis or silicosis. Although many realized that the kind of work done could not be carried on in spotless, hospital-like cleanliness, they felt that conditions might be improved. At least, they said, a clean lunch room should be provided in which the men might open their lunch boxes. Surely that would be better than eating lunch while sitting on piles of material in the shop.

When the Olney High School was evaluated a few years ago, the school plant was marked down a couple of points because of its location across the street from the Olney foundry, for the foundry's noise many times drowns out the voices of teachers and pupils. To the chemistry teachers, however, the foundry has made up those demerits by permitting their pupils to get first-hand information on the work done in a foundry.

SIMPLE, ISN'T IT?

A CHEMISTRY CLASS BEGINS THE YEAR'S WORK

J. G. Manzer
Central High School, Trenton, New Jersey

At the beginning of a school year there is always a good deal of bookkeeping to be attended to: forms to be filled out by each pupil, laboratory desks to be assigned, textbooks to be distributed in exchange for book receipts, and so on. Along with this, it is customary to discuss briefly the nature and value of the subject to be studied, and its place in the education of the pupils—a combination of orientation and pep-talk, illustrated with demonstrations. After this usual introduction, I have for several years started my chemistry classes in a somewhat unconventional way, which I find interesting and which may be of interest to others. Following is an account of the method used and some of its results.

In each class, near the close of the day's chemistry period, I took a battery jar, put a candle in it (fastening it upright with a few drops of melted candle wax), poured in some water (but not enough to cover the candle), lighted the candle, and lowered over it an inverted bottle until the bottle touched the water. Each pupil was then asked to turn in, as homework for the next day, a report on what happened and why.

The reports were interesting. Some pupils had noticed that bubbles escaped at first; all had noticed that the candle went out; most of them had noticed that water rose in the bottle; a few thought that the rising water put the candle out (although it had not risen far enough to do so). Next day in class, when the reports were read and discussed, the importance of accurate observation needed no further emphasis. The demonstration was then repeated, so that all could agree on the observable facts.

As for the second and more difficult part of the question, the explanation most commonly given was that the candle went out because it had used up all the oxygen in the bottle, and that the water rose to take the place of the oxygen used. This explanation raised the question, "Where did the oxygen go?" After discussion, demonstration, reading, and experiment concerning what happens to oxygen when a candle burns, and after some learning about carbon dioxide and water vapor, the question still remained, "Why should the volume of gas in the bottle be less after the burning than it was before?" This led to further work (in class, after school, and at home) on condensation of water vapor, solubility of carbon dioxide, and other factors. Some pupils in their original explanations had already reached this point, although usually not clearly or fully.

By this time the affair of the candle had been going on for two or three days, and it was becoming more involved all the time. We proved, by the usual method, that there was carbon dioxide in the bottle after the candle had gone out. But one of the pupils demonstrated that there was acid in the water, and suggested that at least some carbon dioxide must have dissolved. Every attempted explanation seemed to lead to something else.

About this point, one of the boys threw a bombshell into the discussion when he quoted from our textbook the statement that a candle would go out when the amount of oxygen in the air went down to 17 per cent. This seemed surprising to many, and some took the trouble to experiment in order to find out if there really was oxygen remaining in the bottle after the candle had gone out. They found that there was. At least, they said that iron

filings placed in that gas rusted in the usual way. Others, now more critical than at first, wanted to know how the experiment was carried on. It appeared that iron filings had been pushed up through the water and were therefore wet. It was suggested that the iron filings might have obtained oxygen from the water, which was believed because of its formula to contain oxygen. The experimenter countered by putting iron filings in water and leaving them submerged; no appreciable rusting occurred, while during the same period of time rusting became evident on iron filings in the gas remaining in the bottle after the candle went out.

We were now up against the necessity for explaining how the consumption of 4 per cent of the original air (21 per cent oxygen when the candle started to burn, 17 per cent when it stopped—if we could assume that the 17 per cent figure given by our text was accurate) could lead to a reduction of apparently one-fifth or even one-fourth in the volume of gas in the bottle. We were beginning to question simple explanations.

At this stage the more inquiring pupils began to delve into the quantitative features of the question. There was measuring and calculating of volume, and allowing for the volume of the candle, and waiting for the gas to cool, and trying to catch the bubbles that escaped from the bottle, and so on. One boy determined to analyze the gas remaining after the candle went out, particularly to see for himself how much oxygen remained. He spent most of his spare time for several weeks in devising and testing home-made apparatus for the purpose. He learned something about pyrogallol, and a good deal about the practical difficulties that can arise and the sources of inaccuracy that need to be overcome. Others tried out candles of different lengths, and bottles of different sizes, testing their own hypotheses.

When we finally went on to more conventional subject matter, the pupils had reached various results in their thinking, depending on their interests, equipment, and previous preparation. All were interested, but some were willing to let the matter drop after a few days. A few were more confused than challenged by the complications that appeared, and wanted me to tell them the answer and get it over with. But I did not claim to know all the answers, though I was willing to help them with *their* thinking. We did get together on some explanations that seemed to be satisfactory as far as they went; but certainly no one of these was the full answer to our problem. Some pupils were not satisfied, and kept bringing up further questions, day after day, of their own accord. Some questions could be answered at the time; others were cleared up later in the school year, as we learned more chemistry; and some may still be unanswered. But life's problems are like that: one cannot always demand and receive complete and final answers. And there seems to be no reason for arranging to give our pupils the opposite impression. All agreed that there was much more in the experiment than appeared to a casual observer, and that it would take a great deal of time, effort, and knowledge, and maybe even a little wisdom, to get to the bottom of the subject.

Later in the school year one of the boys brought in a newspaper clipping which described this very experiment, and gave the explanation that water rose to take the place of the oxygen used up. The last line of the clipping read, "Simple, isn't it?" That got a laugh from the class.

A CALENDAR OF THE BIRTHDAYS OF CHEMISTS [1]

James D. Teller

College of Education, Ohio State University

Month	*Day*	*Year*	*Name*	*Birthplace*
January	2	1889	Roger Adams	Boston, Massachusetts
	4	1737	Louis Bernard Guyton de Morveau	Dijon, France
	7	1794	Eilhardt Mitscherlich	Oldenburg, Germany
	7	1833	Sir Henry Enfield Roscoe	London, England
	14	1848	Rudolph Messel	Darmstadt, Germany
	18	1825	*Sir Edward Frankland	near Lancaster, England
	21	1847	Joseph Achille Le Bel	Pechelbronn, France
	25	1627	*Robert Boyle	Lismore Castle, Ireland
	31	1881	*Irving Langmuir	Brooklyn, New York
	31	1868	*Theodore William Richards	Germantown, Pennsylvania
February	7	1834	*Dmitri Ivanovich Mendeléyev	Tobolsk, Siberia
	10	1846	*Ira Remsen	New York, New York
	12	1785	Pierre Louis Dulong	Rouen, France
	13	1672	Étienne Francois Geoffroy	Paris, France
	16	1826	Hans Peter Jörgen Julius Thomsen	Copenhagen, Denmark
	19	1859	*Svante August Arrhenius	Uppsala, Sweden
	21	1822	Oliver Wolcott Gibbs	New York, New York
	23	1817	Samuel Morison Brown	Haddington, Scotland
	28	1814	Edmond Frémy	Versailles, France
March	1	1862	Edward Curtis Franklin	Geary City, Kansas
	3	1879	*Elmer Verner McCollum	Fort Scott, Kansas
	3	1709	Andreas Sigismund Marggraf	Berlin, Germany
	5	1810	Jacob Bell	London, England
	6	1787	*Joseph von Fraunhofer	Stranbing, Bavaria
	7	1869	Ernest Julius Cohen	Amsterdam, Holland
	7	1827	John Hall Gladstone	London, England
	7	1839	Ludwig Mand	Cassel, Germany
	8	1788	*Antoine César Becquerel	Chatillon sur Loing, France
	11	1818	Étienne Henri Sainte-Claire Deville	St. Thomas, West Indies
	12	1832	Charles Friedel	Strasbourg, France
	12	1824	*Gustav Robert Kirchhoff	Königsberg, Prussia
	12	1838	*Sir William Henry Perkin	London, England
	13	1733	*Joseph Priestley	Fieldhead, England
	14	1854	*Paul Ehrlich	Strehlen, Silesia
	20	1735	Torbern Olof Bergman	Vestergötland, Sweden
	24	1820	*Alexandre Edmond Becquerel	Paris, France
	26	1893	*James Bryant Conant	Boston, Massachusetts
	27	1845	*Wilhelm Konrad von Röntgen	Lennep, Germany
	31	1811	*Robert Wilhelm von Bunsen	Göttingen, Germany
	31	1801	Thomas Clark	Ayr, Scotland
	31	1870	Sir William Jackson Pope	London, England

[1] All data are taken from *The Encyclopaedia Britannica*, 14th edition, unless otherwise indicated. Such a calendar is intended primarily as an aid in humanizing the teaching of chemistry. It should prove valuable in suggesting timely and appropriate bulletin board displays and exhibits. The calendar is not intended to be exhaustive but merely suggestive. Classroom teachers would render a service to each other if they would report the ways in which the calendar has been of use to them. Such suggestions are welcomed by the author and will be assembled in a future article with due acknowledgement as to their sources.

* The starred names have been used by the writer in various bulletin board projects, museum exhibits, and assembly programs during the past twelve years.

Month	*Day*	*Year*	*Name*	*Birthplace*
April	5	1827	*Joseph Lister [2]	Upton, Essex, England
	6	1766	*William Hyde Wollaston	East Dereham, Norfolk, England
	8	1818	August Wilhelm von Hofmann	Giessen, Germany
	11	1804	Otto Linné Erdmann	Dresden, Germany
	19	1865	Samuel Avery	Lamoille, Illinois
	24	1787	Mathieu Joseph Bonaventure Orfila	Majon, Spain
	26	1812	*Alfred Krupp	Essen, Germany
	28	1753	Franz Carl Achard	Berlin, Germany
May	1	1824	Alexander William Williamson	London, England
	2	1802	Heinrich Gustav Magnus	Berlin, Germany
	4	1777	Louis Jacques Thénard	Louptière, France
	5	1811	John William Draper	Liverpool, England
	8	1855	Bohuslav Brauner	Prague, Czechoslovakia
	10	1830	Francois Marie Raoult	Fournes, France
	12	1803	*Justus von Liebig [2]	Darmstadt, Germany
	15	1859	*Pierre Curie	Paris, France
	16	1763	*Louis Nicolas Vauquelin	Hébertot, Normandy, France
	19	1857	John Jacob Abel	Cleveland, Ohio
	20	1860	Eduard Buchner	Munich, Germany
	23	1871	Nikodem Caro	Lódz, Germany
June	2	1834	Sir Arthur Herbert Church	London, England
	4	1756	Jean Antoine Claude Chaptal	Nogaret, Lozère, France
	8	1863	Friedrich August Raschig	Brandenburg, Germany
	9	1811	*Hermann von Fehling	Lübeck, Germany
	15	1755	Antone Francois Fourcroy	Paris, France
	24	1835	Johannes Wislicenus	Klein-Eichstedt, Thuringia, Germany
July	2	1842	Albert Ladenburg	Mannheim, Germany
	12	1854	*George Eastman	Waterville, New York
	13	1826	Stanislas Cannizzaro	Palermo, Italy
	14	1863	Paul Walden	Livland, Russia
	15	1800	Jean Baptiste Dumas	Alais, France
	17	1827	Sir Frederick Augustus Abel	London, England
	19	1849	Raphael Meldola	Islington, England
	21	1810	Henri Victor Regnault	Aix-la-Chapelle, France
	24	1843	Sir William de Wiveleslie Abney	Derby, England
	31	1800	*Friedrich Wöhler	Eschersheim, Germany
August	1	1817	Sir Joseph Henry Gilbert	Hull, England
	4	1755	Nicholas Jacques Conte	Aunou-sur-Orne, France
	4	1852	Sir James Johnstone Dobbie	Glasgow, Scotland
	8	1779	Benjamin Silliman	Trumbull, Connecticut
	15	1842	Sir William Augustus Tilden	St. Pancreas, London, England
	19	1830	*Julius Lothar Meyer	Varel, Oldenburg, Germany
	20?	1779	*Jöns Jakob Berzilius	Linköping, Sweden
	21	1816	Charles Frédéric Gerhardt	Strasbourg, France
	22	1857	Giacomo Luigi Ciamician	Trieste, Italy
	26	1743	*Antoine Laurent Lavoisier	Paris, France
	29	1834	Hermann Johann Philip Sprengel	Schillerslage, Germany
	30	1852	Jacobus Henricus Van't Hoff	Rotterdam, Holland
	31	1786	Michel Eugene Chevreul	Angers, France
September	1	1877	Francis William Aston	Harborne, Birmingham, England
	2	1853	*Wilhelm Ostwald	Riga, Germany
	6	1766	*John Dalton	Eaglesfield, Cumberland, England
	6	1828	David Forbes	Isle of Man, British Isles
	7	1829	*Friedrich August Kekule	Darmstadt, Germany
	8	1848	Victor Meyer	Berlin, Germany
	15	1839	George Lunge	Breslau, Germany
	20	1842	*Sir James Dewar	Kincardine-on-Forth, Scotland
	22	1791	*Michael Faraday	Newington, Surrey, England
	27	1818	Adolphe Wilhelm Hermann Kalbe	Elliehausen, Germany
	28	1852	*Henri Moissan	Paris, France

[2] Data taken from *The Encyclopedia Americana*, 1939 edition.

Month	*Day*	*Year*	*Name*	*Birthplace*
October	2	1852	*William Ramsay	Glasgow, Scotland
	3	1858	Percy Faraday Frankland	London, England
	6	1834	Alfred Joseph Naquet	Carpentras, France
	9	1852	*Emil Fischer	Euskirchen, Germany
	10	1731	*Henry Cavendish	Nice, France
	18	1799	Christian Friedrich Schönbein	Metzingen, Swabia, Germany
	18	1844	Harvey Washington Wiley	Kent, Indiana
	21	1833	*Alfred Bernhard Nobel	Stockholm, Sweden
	21	1660	*Georg Ernest Stahl	Anspach, Germany
	24	1854	Hendrik Willem Roozeboom	Holland
	25	1792	Franklin Bache	Philadelphia, Pennsylvania
	29	1827	*Marcellin Pierre Eugene Berthelot	Paris, France
	30	1817	Hermann Franz Moritz Kopp	Hanau, Germany
	31	1835	*Johann Friederich Wilhelm Adolf von Baeyer	Berlin, Germany
November	1	1868	Robert Kennedy Duncan	Brantford, Ontario, Canada
	7	1867	*Marie Sklodowska Curie	Warsaw, Poland
	11	1884	Friedrich Bergius	near Breslau, Germany
	12	1746	*Jacques Alexandre César Charles	Beaugency, Loiret, France
	14	1863	*Leo Hendrik Baekeland[2]	Ghent, Belgium
	14	1891	*Frederick Grant Banting[3]	Alliston, Ontario, Canada
	14	1707	Auguste Laurent	La Folie, Haute Marne, France
	17	1850	Sir George Thomas Beilby	Edinburgh, Scotland
	17	1645	Nicolas Lemery	Rouen, France
	17	1847	Archibald Liversidge	London, England
	18	1789	*Louis Jacques Mandé Daguerre[2]	Cormeilles, Seine-et-Oise, France
	23	1887	*Henry Gwyn Jeffreys Moseley[4]	Weymouth, England
	27	1837	Edward Divers	London, England
	29	1859	Sir Robert Abbott Hadfield	Sheffield, England
December	1	1743	*Martin Heinrich Klaproth	Wernigerode, Germany
	2	1859	Ludwig Knorr	Munich, Germany
	6	1835	Rudolf Fittig	Hamburg, Germany
	6	1778	*Joseph Louis Gay-Lussac	St. Léonard, France
	6	1863	*Charles Martin Hall	Thompson, Ohio
	8	1845	Sir Thomas Edward Thorpe	Harpurhey, Manchester, England
	9	1748	*Claude Louis Berthollet	Tallaire, France
	9	1868	*Fritz Haber	Breslau, Germany
	12	1866	Alfred Werner[2]	Mulhouse, Alsace
	15	1780	*Johann Wolfgang Döbereiner	near Hof, Bavaria, Germany
	17	1778	*Sir Humphrey Davy	Cornwall, England
	19	1742	*Karl Wilhelm Scheele	Stralsund, Sweden
	20	1805	*Thomas Graham[2]	Glasgow, Scotland
	21	1876	Jerome Alexander	New York, New York
	27	1822	*Louis Pasteur	Dole, Jura, France
	28	1818	Karl Remigus Fresenius	Frankfort-on-Main, Germany
	29	1800	*Charles Goodyear	New Haven, Connecticut
	29	1766	Charles MacIntosh	Glasgow, Scotland

[2] Data taken from *The Encyclopedia Americana*, 1939 edition.
[3] Data taken from *American Men of Science*, 4th edition.
[4] Data taken from *The Dictionary of National Biography*, 1921 edition.

VICARIOUS VISITS

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The exigencies of war—military restrictions, accelerated work, transportation difficulties—have curtailed the use of a teaching technique to which science teachers were becoming increasingly partial, that of excursions to industrial plants and laboratories. Under the compulsion of circumstances, more teachers are making use of vicarious visits.

A visit to a power generating plant will show how water power is converted into electricity. Such a visit is no longer possible for most classes. But all may borrow from the United States Bureau of Mines a film which shows well how the energy of the falling water of Niagara is changed into electrical energy. The film does more than this. It leads to an understanding of energy conversion by showing how the energy of falling water is used in simple devices. Later it shows the application of the newly transformed energy, the use of electrical energy in a variety of important industries, and common uses in the home.

If a class is interested in the operation of an internal combustion engine and its role in transportation, a visit may be made to an automobile plant to see how the engine is built. When this is impossible, a Bureau of Mines film on the making of a V-type engine may be shown.

A teacher interested in vocational guidance may take students to visit a variety of plants in order that they may become acquainted with the operations in different industries. Or imaginary visits may be made by means of carefully prepared motion pictures. Many such are to be had—on radio and television, on nursing, and on dairying, to mention only three.

Lists of good films are readily available. The issue of *Education for Victory* for December 1, 1943, published by the United States Office of Education, has a bibliography of sources. A bibliography of visual aids for pre-induction training has recently been published jointly by several interested agencies, including the Office of Education. Even before the war there were available many motion pictures showing processes of importance in science courses, such as the preparation of immune serum, the production of steel, the construction of an automobile, and the mining of coal. The program of industrial expansion necessitated by the war has resulted in the preparation of literally hundreds of films for orienting and instructing workers. Many of these films are already available to schools. They can serve science classes well as they study industrial processes.

Vicarious visits may contribute to the same purposes as actual excursions. These purposes may be:

To clarify textual or verbal description.
To stimulate interest in a process.
To develop good habits of observation.
To study a process in its natural setting.
To study the social setting in which a process is carried on.

However, the use of motion pictures as vicarious visits may have advantages over a real trip. For one thing, a fraction of the time needed to prepare for the experience will yield comparable results in interest and often even better results in learning. In preparing for a class excursion, the teacher must not only discuss the proposed activity with the class in order that teacher and pupil may have similar purposes, but must care for a number of routine procedures. These routines include making schedule adjustments for the children; providing transportation and financing needy pupils; getting the consent of parents so that teacher and school may be absolved of re-

sponsibility in case of unforeseen accident; securing permission from the officials of the plant the class wishes to visit; and instructing children with respect to clothing, conduct, and luncheon. In addition, the teacher should go over the route of the trip in advance, study its educational potentialities, and prepare suitable outlines and questions for the guidance of the class.

The motion picture cannot but be a better organized experience than the excursion. The picture is so filmed that it is logical, coherent, and sequential. Important parts are emphasized by dramatic devices. If at any point a close view is desirable, a close-up is introduced. We may be sure that all children will have an equal opportunity to see what occurs. If an operation is somewhat obscure, an animated diagram makes it clear. Did anyone miss a point? Reverse the picture and repeat the part.

All too often, on the other hand, the experience of a class excursion is something like this: A class arrives at a plant. It is met by a guide. He keeps the group moving at a good pace, for public relations work may not interfere with work progress. No one may loiter to observe closely or longer a particular process, or he may lose contact with the group. Children who keep to the fore may hear and see. If, however, the group is large, those in the rear may learn but little. Even those in front may not see too well, for they cannot get close to the process that is being described. Plants are not laid out for the entertainment of visitors. As a result, one often does not get a clear, sequential view of an entire process, but a fragmentary, unorganized one. Impressions or opinions may be obtained rather than information.

We are not unmindful of, nor ungrateful for, the fine cooperation of many industrial organizations, nor of the values of carefully organized excursions, especially as socializing experiences for students and teacher. But we bespeak a more extensive use of vicarious visits.

The point of this paper may be emphasized by an illustration. Many of us are having our war experiences vicariously. A stay-at-home might relish the opportunity to be taken on a tour of a battle or a battlefield. It is not possible, of course. But he can attend a motion picture such as *Desert Victory*. Here he obtains an authoritative, coherent, sequential presentation of the strategy and tactics that broke the German lines at El Alemain. He could not get as clear a picture on the spot. The heat, dust, noise, and danger are missing. They would add to the vividness of the experience, certainly, but not greatly to an understanding of military strategy.

SOME COMMENTS ON THE ANNUAL SCIENCE TALENT SEARCH

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The Annual Science Talent Search, now in its third year, is of interest to those of us who work with and teach these "scientists in embryo." It should be realized, and too often it is not, that the scientists of the future are among the boys and girls who are now obtaining their secondary school education. Perhaps most of us will agree that the earlier we seek them out, the earlier we guide them along proper roads, the sooner we give them the training which will feed their curiosity, the richer will be the harvest.

Those of us who deal directly with the boys and girls who want to make scientists of themselves realize that the Annual

Science Talent Search is an attempt to do just this—to seek out our young scientists in their pre-college years. Whether or not this is possible remains to be seen.

There are some facts about the Science Talent Search that can be gathered now. How do the youngsters in different schools feel about this search? How do the teachers who work with them react to the search? This paper is primarily a presentation of some material pertinent to the first of these questions.

My observations of students who have applied for and taken the examination lead me to conclude that most of them feel that this is not actually a science *talent* search. Most of them think that a student has a good opportunity to win in the competition if he has very high grades, a good personality, the ability to express himself, and a special interest in book science. They feel that insufficient attention is given to a student's interest in the hard, time-consuming work of the laboratory.

In our laboratories at Forest Hills, there are some youngsters who—in the estimation of their teachers and in the light of the work they have done—will probably make good scientists. It may even happen that one of them will be among the few great scientists of the future.

Three of these students, at least, could not win in the competition, for they cannot express themselves well in English. One is a French refugee; the others are German. They cannot understand the English of the questions (based on statements involving the vocabulary of the college text) and they cannot write the good English necessary for the essay. We teachers cannot help them with their essays, for the contest is for students. And if we did help them, how far could we go before we made the essay ours?

All three youngsters are working successfully on what may be called "original" problems on the high school level. One example may suffice to indicate the true scientific nature of their problems.

Biologists are familiar with the sexual cycle of *Rhizopus nigricans,* of the formation of zygospores subsequent to conjugation. Do those zygospores ever germinate? Some textbooks give figures showing this germination, while at least one states that probably the zygospores do not germinate. One youngster has been working for some time on the problem. His work involves growing the mold in sterile cultures; it involves isolating the zygospores and subjecting them to varied experimental situations fully controlled; it involves constant and thorough hard work. Meanwhile other small problems arise. The zygospores of *Mucor,* closely related to *Rhizopus,* germinate. The zygospores of *Absidia* and *Phycomyces* germinate, those of *Rhizopus* do not. Perhaps the conditions necessary to germination have not been fulfilled? What are these conditions?

I should not want to expose this student to the strain and trial of the examination, for the effort is almost surely hopeless. Yet I have seen several masters' theses with less worthwhile problems; with less commendatory work.

Another of our students will not win, for he won't try. He has problems of personality and very few teachers will recommend him. But he loves science and he spends his time in the laboratory. He might try to enter the contest if he did not know that his personality would be one of the deciding factors. He also is successfully working on a small "original" problem. Do all scientists exhibit fine personalities in their relations with others?

Two others of our good students will try the examinations. They may not win, for contests frighten them. They are retiring, non-competitive students. They abhor contests. They do not think competitions are in the fine spirit of science.

Two more students do not think much of their chances to win. Their grades are good, but not as high as those of some of the students who will enter the contest. These two, however, have recently redis-

covered the protozoan *Chaos chaos* in a pond in the vicinity. This was done after one year of search. A recent rediscovery of *Chaos* (Schaeffer, 1936) merited wide attention. I am having all I can do to make these girls realize the relative importance of this bit of work, even though they have succeeded in publishing a short note in *Science* on the problem.[1] Their insistence that the teacher's name be included as senior author gives evidence of their basic honesty and humility.

I am not against the Science Talent Search. But I have worked long enough with youngsters to realize that this type of search may exclude many high-minded youngsters who want to make science their life's work. These youngsters think of science in a very idealistic way. They feel it is the one field in which truth prevails, where there isn't so much dross. An intelligence test contest doesn't appeal to them. They want to be judged on the basis of the very small contributions to science they have made. It appears to me that much would be gained if the prizes were awarded primarily to those submitting the best "research papers."

After the "research papers" have been read, personal interviews with student and teachers and examination of school records may be helpful in narrowing the search. But students with good minds should not be eliminated because of factors which probably do not enter into the making of a scientist *per se*—facile use of English at the age of sixteen or seventeen, for example, and very high grades.

In a recent article Dr. Hoffman has gone into other reasons why the examination method may not fairly search out the very people desired.[2] These reasons need not be repeated here.

Of course, some data will be furnished twenty years from now when the winners of the past will have had some opportunity to contribute to science. Will we also know of the contributions of those who did not win? It would, of course, be worth while to wait even longer than twenty years to find out whether the tests devised are valid. For if they are, then we are that much nearer to a determination of some of the factors in the proper education of future scientists.

Certainly one may not object to this method of selection of future scientists because it has not been used before. But I cannot rid myself of the feeling that in one sense, at least, this method of selection, as it now stands, falls short of the ideals and attitudes we have learned to associate with science. This, however, is but a feeling.

Nevertheless, I think that most teachers would agree with a method of selection which would emphasize work done in the past—an essay or "paper," school record, personality rating, and interview. Disapproval seems to be centered mainly on the examination which appears to favor the student who works with books rather than in the laboratory. In our school, the students who were successful in the examination seemed to be of just that sort. The students who spend most of their time in the laboratory had less time to spend with books. But they learned to go to source material when they required information.

Dr. Hoffman levels his guns mainly at the examination. I agree with him. Scientists in the past have been given the opportunity to continue their work on the basis of the work they have done. They do not, in the main, take an intelligence test for a new position. Shall we not bring this principle of operation, proved successful here, to the method of selecting our future scientists?

[1] Brandwein, P. F., Penn, Patricia, and Shiel, Clare. "A Rediscovery of Chaos Chaos." *Science*, 98: 431, 1943.

[2] Hoffman, Banesh. "Some Remarks Concerning the First Annual Science Talent Search." *American Scientist*, 31: 255–262, 1943.

NOTES AND COMMENTS

SOME CLASS ACTIVITIES IN BIOLOGY

IN our industrial community it has been a comparatively easy matter to interest students in chemistry and physics. Many students feel that when they become workers in local industries they will apply what they have learned in these subjects. Biology students, however, at first have little enthusiasm for the study of "living things." Living things appear to constitute a very small part of their immediate environment. Biology seemingly offers few monetary rewards.

All available land space in an industrial community is likely to be taken up by industrial plants and the homes of the workers. Swamps which served as a refuge for wild life have been filled in to make room for industrial expansion. Streams are polluted with industrial wastes, and plant and animal life no longer flourishes there. The few undernourished trees and shrubs in the community struggle against the poisonous effects of industrial gases and poor soil. Birds and other wild life have sought a more desirable environment in the woods and open fields.

I am not saying that the study of biology has little to offer in such a community or that the students do not find biology of value to them; but I am frank to say that there is always something of a struggle to develop at the beginning enthusiasm for the study of "living things."

It has been customary in the teaching of biology at George Rogers Clark High School to devote one class period each week to student reports on current topics, or to discussions of subjects which have been selected by the group. This year the students decided that it would be a good idea to select a theme on which to base their reports on current material. The theme chosen for the year, "Biology Has Gone to War," awakened an interest in biology from the start. This year the subject is not just a study of "living things" but of how man's knowledge of living things is playing an important part in winning the war. The students have been able to see the value in knowing some of the facts and basic information concerning topics such as the following:

- The control of insects and plant diseases.
- Ecology as a background for the successful growth of refugee crops.
- Wayside plants as substitutes for shortages resulting from war with Japan.
- Plant and animal substitutes for vital war materials.
- The relation of soil composition and structure to plant growth.
- The necessity for prevention of the kind of soil erosion which resulted from the last world war.
- The preservation of foods.
- Foods in relation to health.
- The control of epidemics.
- New developments in the field of medicine.
- The biological effects of high altitude flying and of prolonged exposure on life rafts.
- The effects of fatigue from overwork and worry.

As a result of their enthusiasm for this organization of current material, the students have decided to adopt "The Problems of Post-War Biology" as the theme for their group discussions. The following are a few of the topics already suggested for this part of the work:

- How can we reduce the number of health deficiencies which came to light through selective service examinations?
- Should young people be encouraged to go back to the land?
- What factors are demanding a reorganization of our thinking on race problems?

Another current activity of the biology classes is related to this last question. Ten minutes of each class period is reserved for reading or discussing the biography of George Washington Carver. Students ad-

mire the strength of character, genuine interest in living things, keen understanding, and spirit of the scientist that they find in this man's life. They obtain a clearer idea of applied biology and of scientific method from reading of his activities than they seem to get from biology textbooks.

VEVA MCATEE
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PROJECTS IN NUTRITION STUDY

IT was project day in the biology class. The topic of study, "The Dietary Needs of Man," was divided into eight areas or problems. The problems were:

1. What foods are eaten most in your home and in your neighbors' homes? Which foods are liked best? Which least?
2. What is the calorie content of foods in the seven basic food groups?
3. What are the essential vitamins and minerals in foods? Which foods contain these? How are they used by the body?
4. What are the vitamin-deficiency diseases? What are some food allergies? What is dental nutrition?
5. What is a balanced diet for wartime living? What are the ration points (if any) for each item listed?
6. What are some nutritious ways of preparing food to extend the food supply and to overcome waste? What are the uses of soybeans?
7. What fruits, vegetables, and meats are in greatest demand in the city's markets? Where do these come from and what are their prices? What frozen and dehydrated foods are available?
8. What are some food fads widely advertised in magazines and newspapers and over the radio today?

Each area had been studied by a committee of four students. Now the chairman of each committee was presiding in turn over the class, and the committee members were presenting the results of their work to their fellow-students.

The first committee had interviewed eleven families consisting of thirty-one people. The committee reporting the second project suggested that each student compute the calorie content of his diet for several days to determine whether he was meeting the daily calorie requirement for high school boys or girls. A scrapbook had been prepared about vitamins and minerals. Bulletin boards presented a tempting exhibit of menus and nutritious foods. A student acted as "food expert"; he discussed food extenders and gave illustrations of food waste. One committee presented an original playlet to illustrate the advantages of good diet over vitamin preparations. As each project report was given orally, a written copy was filed with the class secretary. The exhibit material was to be left on display until the completion of the unit on foods.

During their group study, the students had made use of a variety of sources of material. They had studied the booklets, *You and Your Food*, by Leila Wall Hunt,[1] and *The Road to Good Nutrition*, by Lydia J. Roberts.[2] They had consulted pamphlets on wartime menus, nutritious foods, and food extenders from the Nutrition Division of the Office of Defense Health and Welfare Services, the United States Bureau of Home Economics, the United States Department of Agriculture, and the War Food Administration. They had used current magazines and newspapers for exhibit material. They had reviewed radio programs. They had made trips to the large central city market and to neighborhood grocery stores. They had visited food exhibits prepared by the home economics classes.

Before the committees began their work, each member of the class had kept a chart of his daily diet for one week. These charts are to be checked for errors after completion of the study of dietary needs.

[1] Hunt, Leila Wall. *You and Your Food.* Extension Service, State College of Washington, Pullman, Washington (no date).

[2] Roberts, Lydia J. *The Road to Good Nutrition.* U. S. Government Printing Office, Washington, 1942.

At the end of the present semester new charts will be made to determine the extent to which the information learned has been applied. The projects have proved so stimulating to the students that the teacher hopes to find real dietary improvement at that time.

CHARLOTTE L. GRANT
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PUTTING THE UNIT ON CELLS TO WORK

THE unit in which we develop the concept of the cellular structure of living things is one of the oldest in the biology course of study. It is generally regarded, and rightly so, as a "background" unit necessary for the appreciation of physiological processes, growth, and heredity. At the time it is taught, however, it is seldom given any practical emphasis. It is here suggested that the unit may be utilized *at the time it is taught* to make a contribution to two important aspects of our biology teaching, namely, (1) nutrition, and (2) cancer education.

In studying epithelial cells, their sensitivity to a lack of vitamin A may be mentioned. Similarly, in studying the cellular structure of bone the dependence of bone cells on an adequate supply of calcium, phosphorus, and vitamin D may be emphasized. The dependence of nerve cells for perfect functioning on an adequate supply of thiamin may be stressed. The need for iron and traces of copper may be pointed out in the study of blood cells.

The study of the organization of cells need not stop at the definition of *tissue* and *organ* nor at the distinction between *differentiation* and *specialization*. The class may go on to consider the condition in which cells go berserk and proliferate into abnormal growths. Emphasis should be placed upon the extreme importance of the early detection of such growths and the possibility of arresting them in time to avert an untimely death from cancer.

It is not suggested that these emphases can or should take the place of a nutrition unit or of a direct attack on the cancer problem.

ZACHARIAH SUBARSKY
Bronx High School of Science
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LABORATORY DIRECTIONS BY MEANS OF MOTION PICTURES

FOR a high school youngster the dissection of a frog is a formidable operation. Laboratory directions, no matter how well written, do not suffice to enable the student to dissect with confidence. A preliminary demonstration by the teacher is difficult because it is almost impossible to have an entire class of thirty to forty students witness the demonstration at once. Even if it were possible, students would find it difficult to remember the steps.

To overcome these difficulties we have produced a motion picture film at the Bronx High School of Science by means of which the students see the dissection step by step. The steps photographed are:

Laying out dissecting instruments.
Pinning frog to dissecting tray.
Skin incisions.
Pinning back skin.
Muscular wall incisions.
Pinning back muscular wall of the abdomen.
Probing the alimentary canal.

The suggestion is here made that motion pictures may prove equally valuable as a means of giving laboratory directions in other comparable situations.

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THE VICTORY GARDEN AND THE STUDY OF BIOLOGY

THE Victory Garden has given us a focal point for much of our work in biology during the fall of 1943. The topics emphasized in biology classes included:

Care and Storage of Foods. This has seemed especially important this year in a region where a high per cent of the population has access to a garden.

Care and Storage of Next Year's Seed Supply. This study seems justified from the standpoint of economy alone. Germination tests by various methods were used. Some study was made of the length of time various kinds of seeds retained their normal vitality. The number of days required for germination of seeds was considered. Maturity tables were also used in this connection.

Soils of the Victory Garden. Consideration has been given to proper uses of crop residues, green manure crops, and of manure from animals. Samples from various garden plots of the area were tested. An investigation of the plots and the testing of soils will enable some of the students to make better use of their gardens next year.

Fighting Garden Enemies. A good deal of insect study was introduced under this topic. An attempt was made to learn more about the insect and animal pests and diseases and about proper methods of controlling them. Fungicides and insecticides and their comparative costs and merits were discussed.

These studies have branched out into topics on hydroponics, pruning and repairing, and grafting. In all this work the help of various agencies has been enlisted. The city nursery, the state college, the local county agent, and the 4-H movement have all assisted.

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AUTOMOBILE PARTS USEFUL AS LABORATORY EQUIPMENT

AUTOMOBILE electrical shops and garages are valuable sources of equipment useful in the teaching of science.

A storage battery may be used in place of dry cells which are difficult to obtain at present. Many batteries not capable of delivering the large current (approximately 100 amperes) required by the automobile starter will give satisfactory service in the laboratory and can be obtained at a very reasonable price. A storage battery is particularly useful in experiments involving magnetism or heat because of the large current it can produce. The storage cells show a practical use of the hydrometer. Six-volt lamps having the same base as the standard 110-volt lamps are available and can be used with a storage battery in circuits showing house wiring. This method eliminates the danger of electrical shock and makes possible the use of direct-current meters.

The battery may be charged by means of an automobile generator driven by a one-fourth horsepower motor operating on the house circuit. The two units may be connected by means of a V-belt and pulleys or the two shafts may be directly connected by a short piece of garden hose slipped over them and prevented from slipping by hose clamps. The process of charging will show the parts and operation of a direct-current generator and will demonstrate that a direct-current generator will run as a motor. A generator cut-out should be installed as it not only shows the operation of the device but demonstrates the principle of the relay. This circuit should also contain an ammeter.

The action of a rectifier tube may be demonstrated by the following circuit. One wire from a 110-volt alternating current line is connected to a 10-watt 110-volt lamp in series with one filament connection on a

type 80 radio tube. The other wire from the house circuit is connected to the plates of the tube. The filament is heated by two cells of a storage battery. The rectified current and voltage are measured with direct-current meters.

The use of the type equipment suggested above has the following advantages:

It is available under present conditions.

It is reasonable in price.

It is effective in teaching because the student realizes that it is the type of equipment with which he will work when out of school.

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THE USE OF STRIP FILMS IN PRE-INDUCTION AERONAUTICS

STRIP films make effective visual aid materials when they can be used at the proper points in the lesson. They are not satisfactory unless they are available whenever they fit into the discussion.

To illustrate the statements made above, let us take the case of strip films available as visual helps for pre-induction aeronautics courses. Excellent strips are available for navigation, meteorology, aerodynamics, and other subjects, and follow closely the material of such courses. The subject matter of the various strips has been developed in cooperation with the Civil Aeronautics Authority program and is authentic, well arranged, and can be a real aid to teaching.

We find, for example, that to run through the strip about charts as we go into the study of chart reading is quite helpful. A second viewing later seems to tie everything together very well.

Some teachers, however, do not have appropriate strips available when they are beginning the study of a topic. For them, the later or earlier showing of the strip is possible, but not nearly so profitable to their pupils. Evaluation of accomplishment seems to indicate that the late or early showing of a strip is no more productive than the same time spent in some other way more directly connected with the work the pupil is doing at that particular time.

On the basis of past experience with slides, strip films, and motion pictures, we have come to the definite conclusion that some subjects in pre-induction aeronautics can better be treated visually without motion than with motion. The slower rate of projection, the lengthened period for discussion of each picture, and the ease with which one can show selected portions of a strip argue in its favor.

We have found the storage problem much simplified with the strip films as contrasted to the more bulky slides. Seventy or eighty "frames" can be stored in a small container which occupies little space. Then, too, slides are subject to breakage with rough handling; carelessness with strip film may result in damage also, but our experience has been good in this respect. Finally strip film projectors are much smaller than slide projectors, and occupy less space.

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BOOK REVIEWS

GLASS, BENTLEY. *Genes and the Man.* New York: Bureau of Publications, Teachers College, Columbia University, 1943. 398 p. $3.50.

To show how the interaction of hereditary and environmental factors determines every characteristic of any individual is the thesis of *Genes and the Man.* Just as we need to know something of the history of America in order to understand issues confronting our society and government, so we must know as much as possible about the past life of a man: the origin of the organism, the heredity pattern, the processes of growth and development, and the surroundings, prenatal and external, in which the individual lives. Only when we have assembled all our scientific knowledge about the human organism and interpreted it in terms of racial history and in terms of the goal of mature fitness for life activities can we really know and understand a human being.

Genes and the Man is the fifth volume of basic science material in the series known as "Science in Modern Living." The books were prepared in the Bureau of Educational Research in Science under the administration and editorship of Professor Samuel Ralph Powers, head of the Department of Natural Sciences, Teachers College. In line with the general education viewpoint, the series has been planned to meet the needs of teachers, and particularly of curriculum workers, for authoritative science in relation to important issues of today. The widespread confusion about the genetic basis of race and the efforts of teachers to help their students understand the contribution of science to the problem makes this book especially timely.

Going beyond a mere integration of the fields of genetics, cytology, embryology, and physiology, this book shows us how our present specialized knowledge of genetics, reproduction, and growth and development enables us to understand human life—its epic sweep from conception to death, "together with those tenuous physical bonds," the chromosomes, "which link each generation with all before and after." For example, it is futile and erroneous to search for the meaning of sex in "obscure realms of emotion or social influence without that sure sense of direction which can come only with an understanding of its biological function and evolution." Life and environment at the level of cells and genes are no more separable than at any later stage of development. "Our hereditary pattern is in a sense only the accumulated hereditary control of our race over certain features of our environment." As in postnatal life, genetic and embryological development is "progress toward greater effectiveness, brought about through an increase in the number of associated life-units and by a division of labor among them." An organism represents interdependence at its best. Natural senescence is only the wearing out of physiological mechanisms, and "with each man there perishes," at death, "the unique assemblage of genes that along with the ever varying environment made him what he was. But the genes themselves, cast into new arrays in the reproductive cells, are as immortal as life itself."

Lending to the interest and usefulness of the book are discussions of several striking analogies. For example, on pages 232–234, the author points out that, although there are differences between the relation of cells to the human body and the relation of individual men to human society, they are not so fundamental as one might at first suppose.

Even accidents enter the genetic picture. Although we are inclined to consider causes of accidents as wholly external to the human body, we must not overlook such items as individual characteristic speeds of reaction, which play an important role in automobile driving. "Heredity, past development, experience, external circumstances, and chance are all inextricably concerned in determining the outcome" of any mishap.

By beginning with a single cell, tracing its continuity with earlier generations of cells, analyzing the nature of its development as complex factors interact on one another, and concluding with a descriptive account of prenatal and postnatal growth and development, maturity, and senility, Professor Glass leads the reader to comprehend the physical man as an organism made up of interacting factors whose behavior is influenced by and influences the environment.

—C. V. Meeting.

STARR, VICTOR P. *Basic Principles of Weather Forecasting.* New York: Harper and Brothers, 1942. 299 p. $3.00.

This volume is devoted exclusively to the principles and problems of weather forecasting. It formulates a systematic approach to the subject and is based upon extensive teaching and research at the University of Chicago. The major portion of the text is concerned with short-period forecasting, about thirty-six hours in advance. One unusual chapter is on the new technique of forecasting, based on reports from a single station, whereas ordinary methods require a knowledge of existing weather conditions over an extensive network of reporting stations. There are nearly a hundred illustrative maps and charts.

The textual material is not easy reading and would be more suitable to intermediate or advanced meteorological courses now being taught in several specified colleges.

—C.M.P.

ABSTRACTS

Anonymous. "Brightest Star is Twins and Each One a Giant." *Science News Letter* 56: 360; December 5, 1942.

The brightest star known is S. Doradus about 95,000 light years away. It is 600,000 times brighter than the sun. It has recently been found to be a double star, one star revolving about the other in about 40,000 years. Each star is about the same size—1,800 million miles in diameter.

—C.M.P.

Armagnac, Alden P. "Atom Smashers Solve the Mystery of the Sun's Energy." *Popular Science Monthly* 141: 50–53; July, 1942.

The sun's energy results from a half-dozen successive reactions involving the carbon cycle in which hydrogen is the fuel of the reaction and helium the ashes. Carbon acts as the catalyst in the reaction. This chain reaction requires about 6,000,000 years according to Bethe, Professor of Physics at Cornell University.

—C.M.P.

Thone, Frank. "Cultivating by Fire." *Science News Letter* 43: 106, 108; February 13, 1943.

Flame cultivation is a new way of fighting weeds that is being adapted to agriculture. Flame from burning oil is applied to weeds from a device that resembles a cultivator. Weeds are even killed between plants in the same row. Weeds are killed because they are lower than the other plants such as cotton, corn or cane. Weeds are not killed immediately but soon die. The greatest advantage of this new and seemingly most effective agriculture tool is the economy in time in killing weeds—saving the time of at least 20 men with hand hoes. Many harmful insects are also killed, erosion is lessened and better mulch results.

—C.M.P.

Sonnedecker, Glenn. "Plowing Goes Underground." *Science News Letter* 42: 298–299; November 7, 1942.

This new method of subsurface plowing may revolutionize American farming. The stubble and surface coverage is left standing as the new plow with odd-shaped blades cuts through the soil without turning it over. No more long furrows of upturned sod. The new method conserves moisture and prevents erosion. Its use is likely to become quite widespread.

—C.M.P.

Grahame, Arthur. "Why America's Tanks Are the World's Best." *Popular Science* 142: 120–127, 218–221; March, 1943.

American tanks excel in more powerful guns, better and heavier armor plate, greater speed, longer wear. There are several illustrations including eleven showing the evolution of American tanks from 1917 to 1940. —C.M.P.

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